Passive House Multifamily Construction

Hook & Ladder – Minneapolis, Minnesota

Presented by Kim Bretheim, FAIA, LEED AP BD+C – Housing Studio Leader

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

Learning Objectives

1. Case study comparison
2. Why Passive House for multifamily affordable housing?
3. Review outcomes
4. Compare “standard” and Passive House requirements
5. Compare constructability and detailing

Project Context

HOLLAND NEIGHBORHOOD ART ENERGY INNOVATION IMPROVEMENT ASSOCIATION

- Art
- Energy
- Innovation

Project Statistics

Building 1: Standard

- 59 Units (32-1BR, 16-2BR, 11-3BR)
- 3-story wood frame over 1 level precast
- 46,595 net rentable SF
- 59,553 GSF finished
- 19,768 GSF enclosed parking below

Building 2: Passive House

- 59 Units (32-1 BR, 16-2 BR, 11-3BR)
- 4-story wood frame over 1 level precast
- 47,856 net rentable SF
- 57,869 GSF finished
- 9,296 open parking below

Climate Zone: 6A

Primary Occupancy: R-2

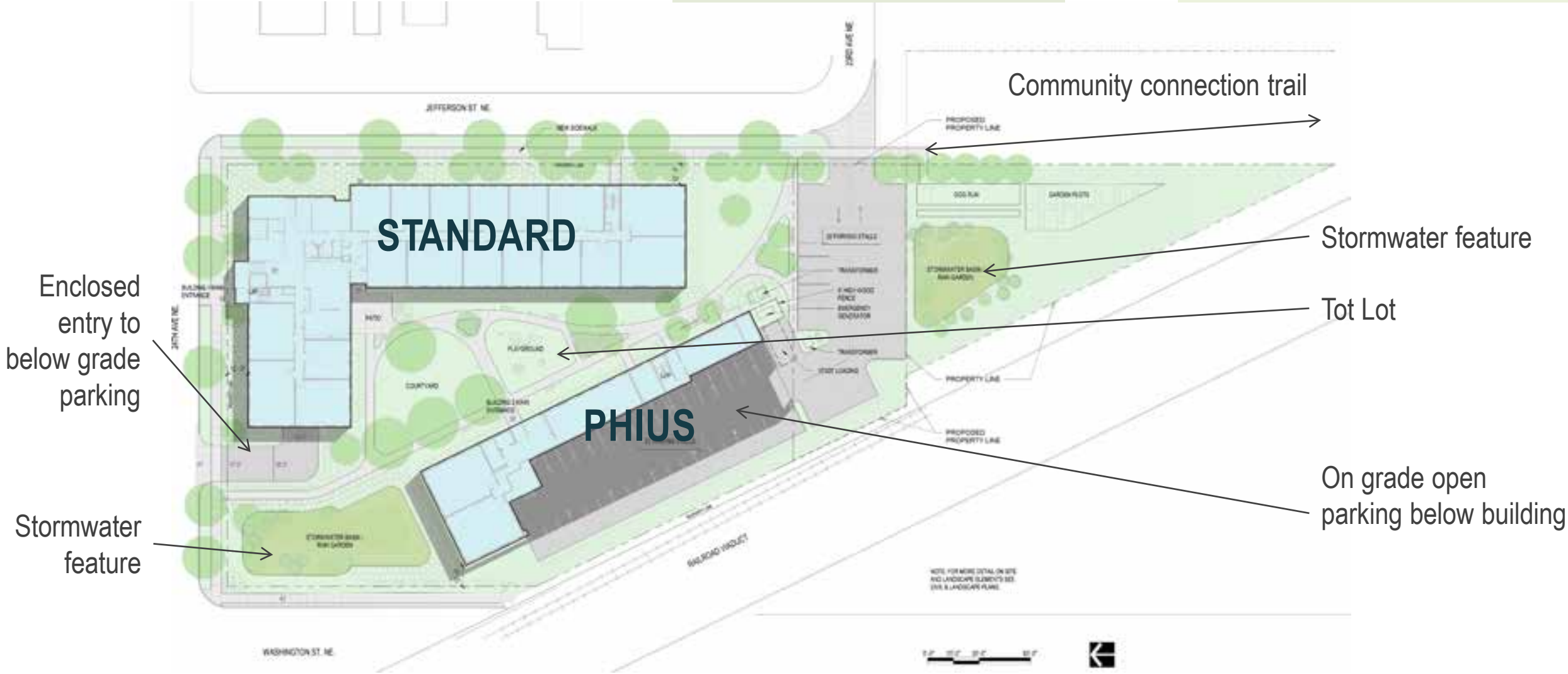
Construction Type: “Standard” Building 1: VB

“Passive” Building 2: VA

Project Site

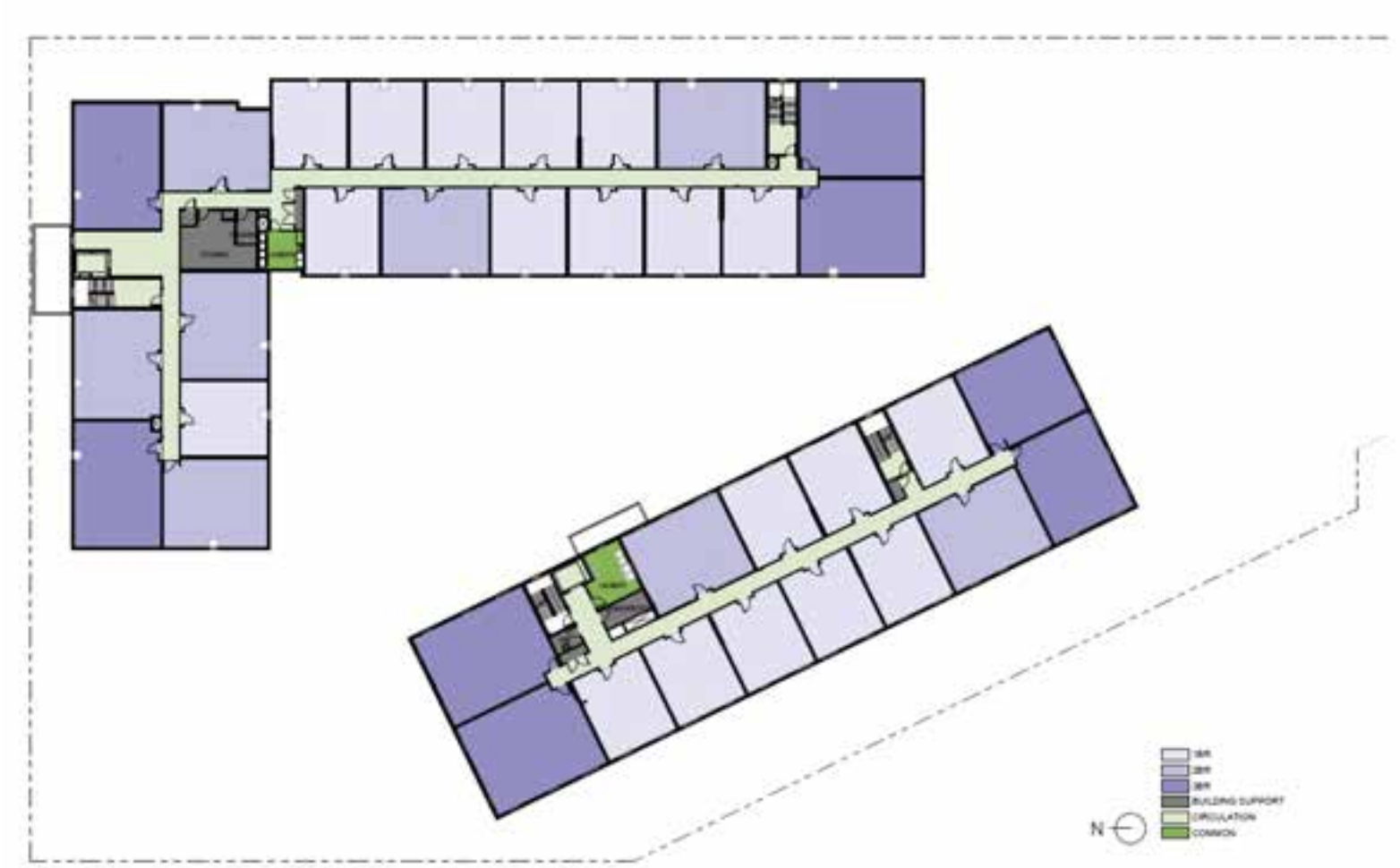
Standard Building
- 3-Stories over underground parking garage
- 59 Dwelling Units
- Rentable Unit Area = 45,628 SF

Passive House
- 5-stories with unenclosed parking on Level 1
- 59 Dwelling Units
- Rentable Unit Area = 45,883 SF

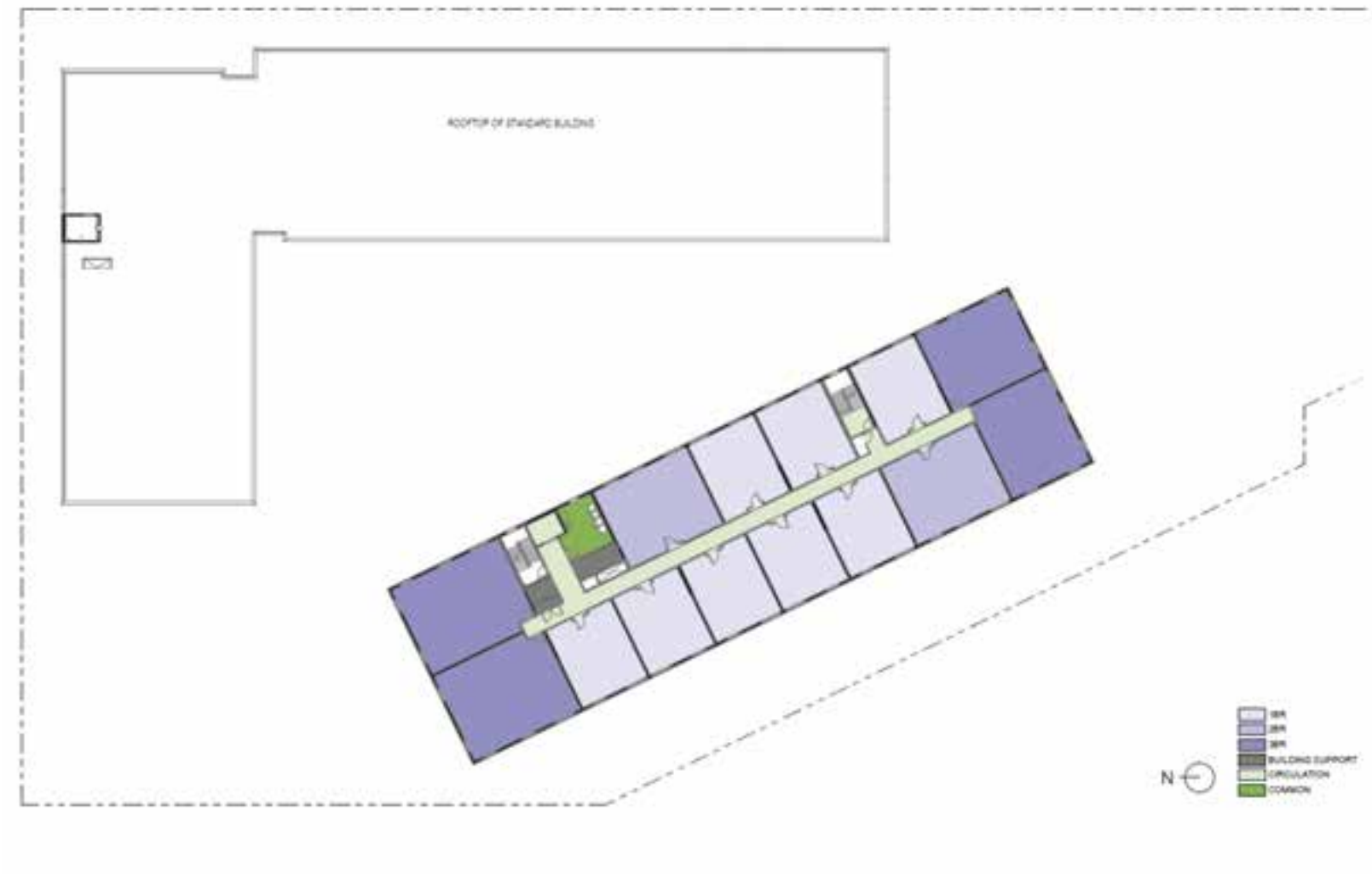


First Floor

Second – Third Floor



Fourth – Fifth Floor



Outcome

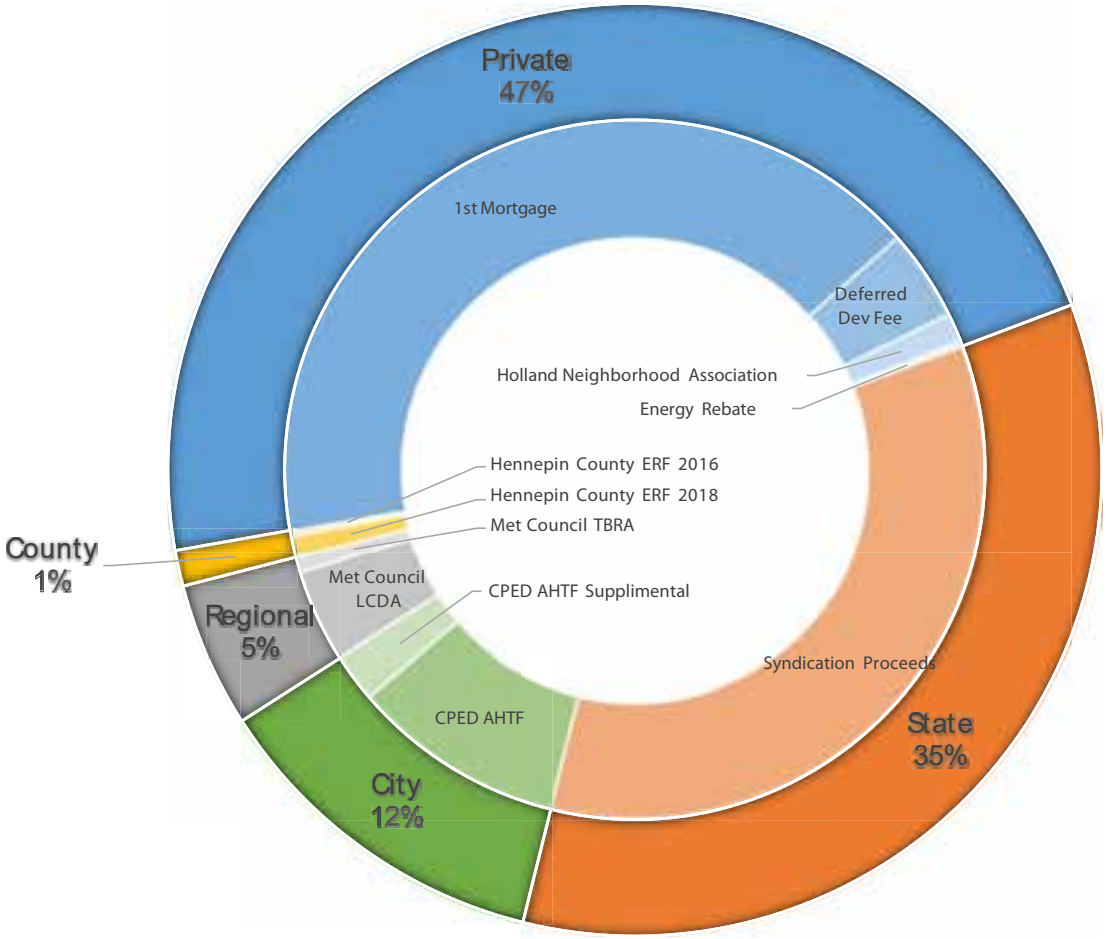
Outcome

ENERGY USE INTENSITY (EUI = kBtu/sf/yr)		
	Standard Building (with enclosed parking)	Passive House Building (without enclosed parking)
EUI Baseline	75.4	66.7
EUI Goal	62.3	40
EUI Predicted	56.7	23.75

AIR TIGHTNESS (Blower Door Air Leakage Tests) Code Maximum: 3 ACH_{50}		
	Standard Building (with enclosed parking)	Passive House Building (without enclosed parking)
Design Standard Max	Energy Star Max = .3 ^{cfm} 50/ft	PHIUS = .05 ^{cfm} 50/ft
	.15 ^{cfm} 50/ft^2	.038 ^{cfm} 50/ft^2
	.95 ACH_{50}	.3 ACH_{50}

Standard Building
HERS Rating:
61 Target
51 Actual

Cost Containment: Finance Sources / Construction Cost



PHIUS BUILDING TOTAL COST
Excluding site
$10,020,951 = $149.20/GSF w/ parking
$163.53 GSF w/o parking

STANDARD BUILDING TOTAL COST
Excluding site
$9,547,675 = $120.37/GSF w/ parking
$140.41/GSF w/o parking

Why PHIUS for Multifamily Affordable Housing: Benefits

PHIUS+ 2015 REQUIREMENTS

- High-performance building envelope
  - Thermal comfort
  - Moisture control
  - Durability
- Fresh air requirements
  - Direct bedroom supply
  - MERV 8 (MERV 12)
  - Limited exposure to combustion gas
- Balanced ventilator

OCCUPANT BENEFITS

- Resilience
  - extreme weather
  - power outages
  - housing cost uncertainty
- Remediation of environmental pollution
- Increased occupant comfort
- Increased occupant health
  - reduction in mold, bacteria, dust, pests
  - cardiovascular
  - stress

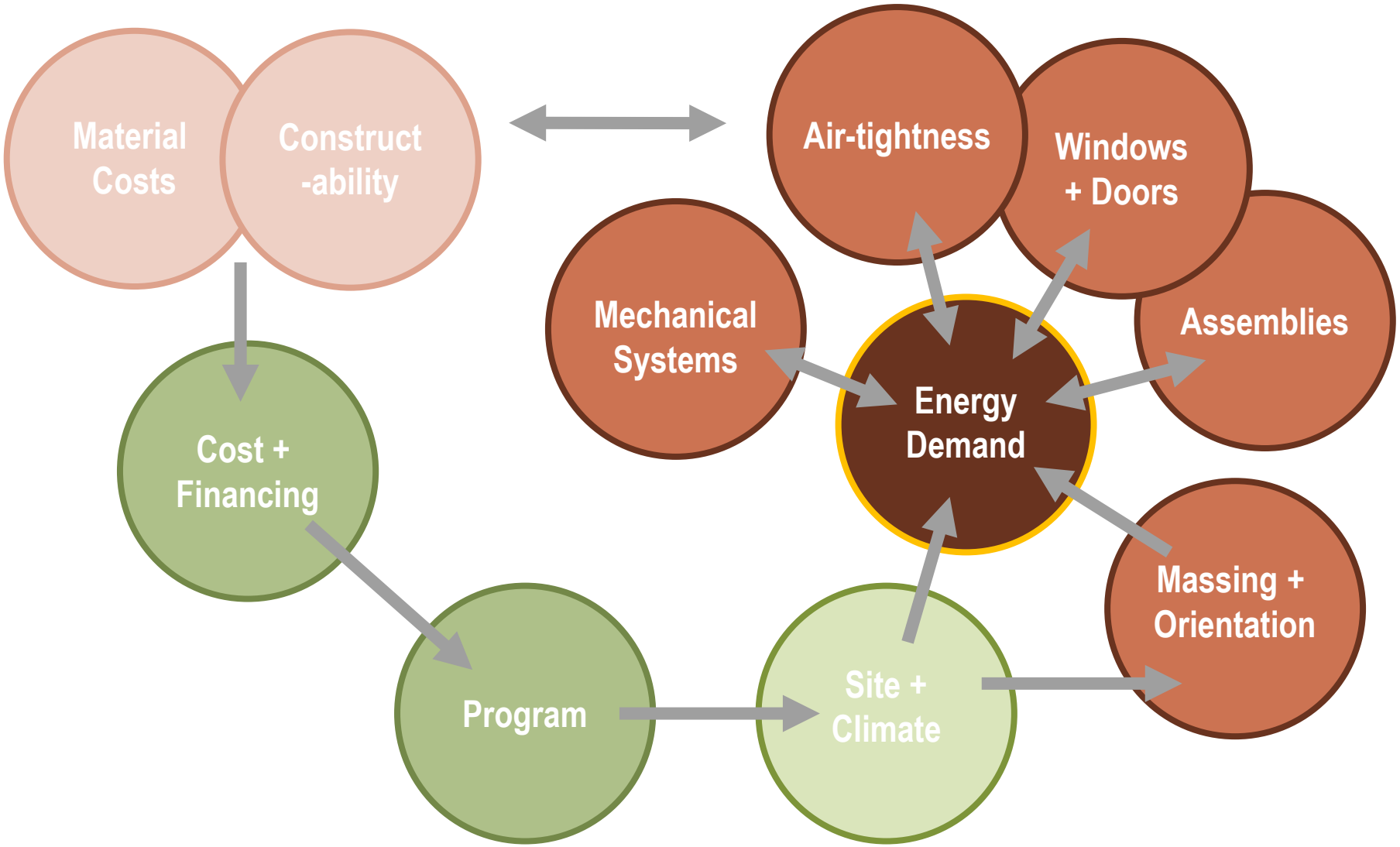
COMMUNITY BENEFITS

- Lower turnover = connection to community
- Resilience
- Proactive care for vulnerable populations
- Economics
- Emissions
- Prototype

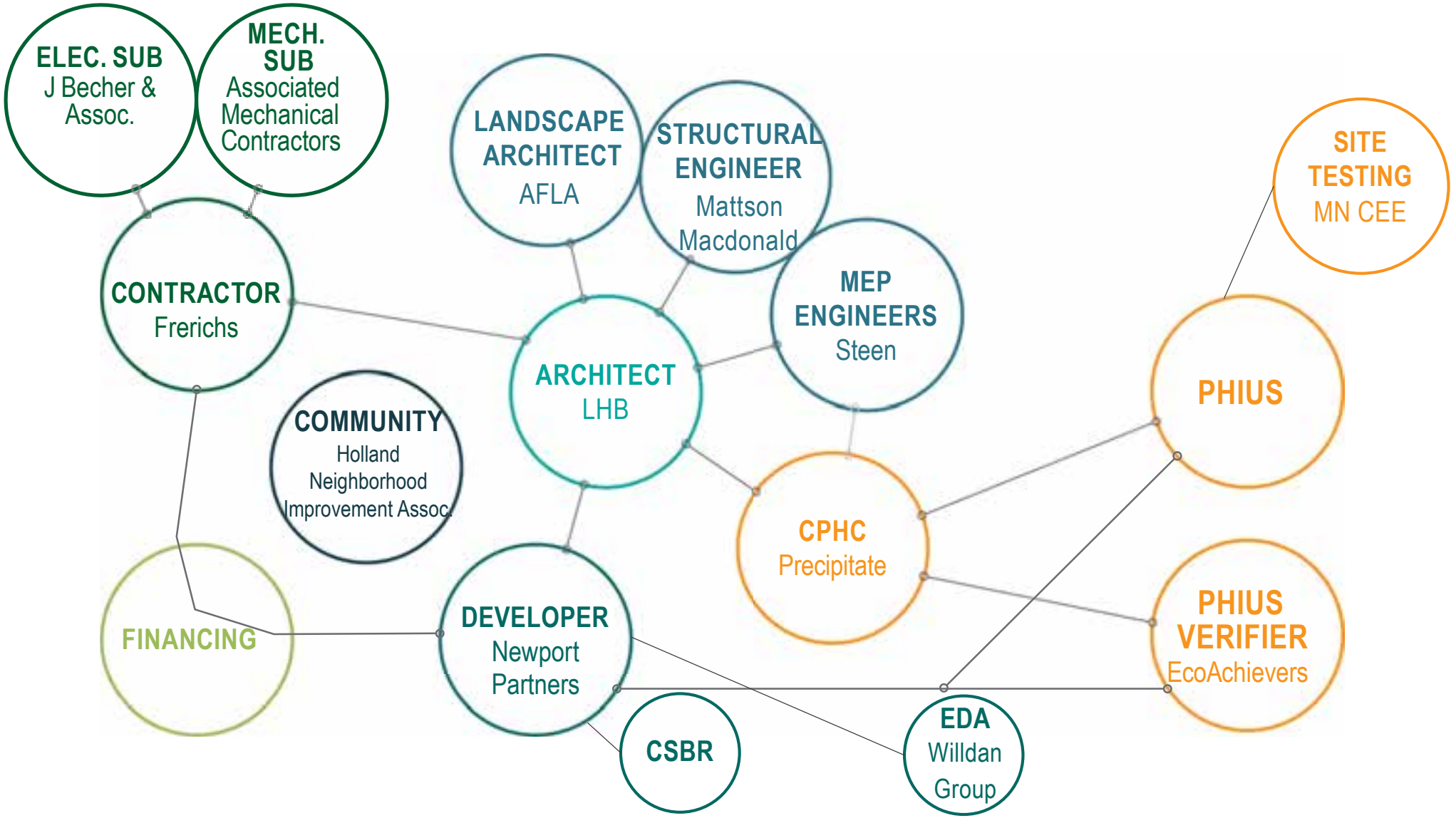
OWNER BENEFITS

- Funding opportunities
- Reduced maintenance/ operation costs
  - utilities
  - envelope durability (3rd party verified)
  - Reduced resident turnover

Integrated Design Critical to Success



Development Team Relationships



Project Team

OWNER: NEWPORT PARTNERS LLC

- Becky Landon
- Sarah Larson

ARCHITECT: LHB, INC.

- Kim Bretheim, Project Principal
- Bailey Hanson, Architect
- Laura Heck, Project Assistant
- Jeff Hemer, Architect
- Melanie Kiihn, Architect
- Lindsey Kieffaber, Architect
- Andy Madson, Architect
- Bill Niebur, Architect
- Roger Purdy, Construction Administrator
- Jonathan Rozenbergs, Architect
- Stuart Shrimpton, Architectural Designer
- Ben Trousdale, Architect
- Elizabeth Turner, Architect
- David Williams, Energy Modeling

PASSIVE HOUSE CONSULTANT: PRECIPITATE

- Elizabeth Turner, Architect, PHIUS+ Consultant

CONTRACTOR: FRERICHS CONSTRUCTION

- Dave Einck, Senior Project Manager
- Mike Reineccius, Field Superintendent
- Aaron Zdon, Air Sealing Specialist

M&E CONTRACTORS

- J. Becher & Associates
- Kevin Miller & Reid Mathiason: Associated Mechanical Contractors

M&E: STEEN ENGINEERING

- John Hazucha, Mechanical Engineer
- Jake Melbostad, Electrical Engineer

STRUCTURAL: MATTSON MACDONALD YOUNG

- Kirk Davis, Structural Engineer

CIVIL: WENCK ASSOCIATES

- Roshaan Grieme, Civil Engineer

LA: AUNE FERNANDEZ LANDSCAPE ARCHITECTURE

- Jason Aune, Landscape Architect

Passive House Principles

Minimize Thermal Loss/Gain

- Continuous Insulation

Air-Tight Construction

- Proper location and durability of air barrier and vapor retarder

High Performance Windows/Doors

Balanced Ventilation (ERV)

Minimized Space Conditioning

PHIUS Certification Process

Certified Passive House Consultant

WUFI Passive Energy + Hygrothermal Modeling

Pre-certification Design Review by PHIUS

Testing by PHIUS+ Rater (HERS rater allowed first time)

- Detailed on-site inspection
  - Slab + foundation insulation
  - Insulation
  - Air barrier details
- Blower door test
- HVAC + DHW commissioning

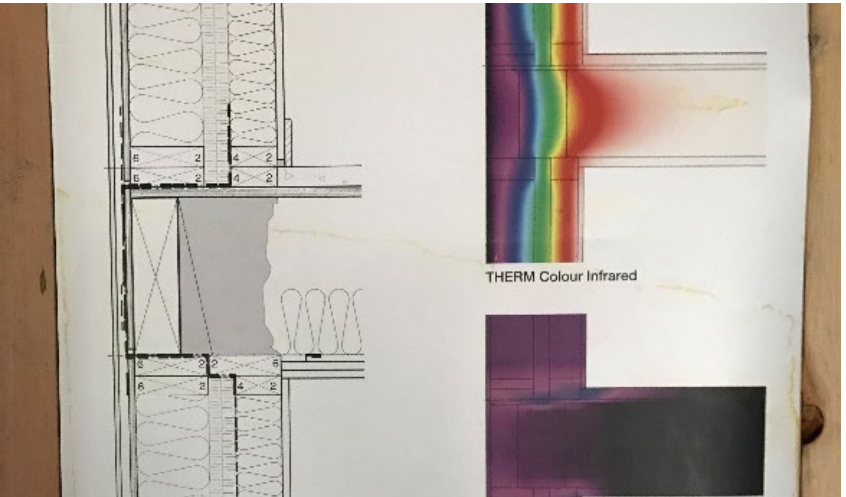
Design Performance Standards

Thermal and Moisture Protection / Window Openings

	Building: 1 Standard	Building: 2 PHIUS
Standard	Energy Star Certified Homes, Version 3.1 rev.08 Maximum Assembly U value per ASHRAE 90.1-2010, appendix A per MN Residential Energy Code C401.2.	PHIUS Energy Star Multifamily High Rise. Version 1.7 MN Commercial Energy Code
Insulation level modeling	2012 IECC levels (table 402.1.3/1) and grade 1 installation per RESNET standards	Meet or exceed 2012 IECC insulation levels (ASHRAE 90.1-2010)
Slabs on grade	Slab edge R5 + per 2009 IECC	below slab insulation: whole slab R20-28
Wood Framed walls min.	(U-.051)	continuous exterior insulation +R5 (Walls: 39-51)
Roof minimum:	1) Above deck: R30 (u-.032)/.048	(Roof/Ceilings: 70-90)
Floors over unconditioned space (minimum)	U=.033 (per energy star 3.1)	U=.026 blown insulation in framing plank

	Building:1 Standard	Building: 2 PHIUS
Standard	Ufactor and SHGC for northern zone	meet PHIUS for cold climate zone (#6)
U factor	-.27 -.30 U	Overall Installed Window U-value: < 0.13 (Btu/h)/sf/F Center of Glass U-Values: < 0.12 (Btu/h)/sf/F
Air leakage	.3 cfm 50/s.f. per Energy Star	.05cfm 50/ft2 (whole building)
SHGC	.32 - .42	SHGC-South: > 0.50 SHGC-North, East, West: Any
Models meeting standard/certification	Pella Impervia – Natural Sun Low-E IG (.29 U, .5 shgc)	**Pella** 350 series (Advanced low-e argon triple pane – U=.17, shgc+.19)

Precedent: Vancouver – Envelope & Constructability



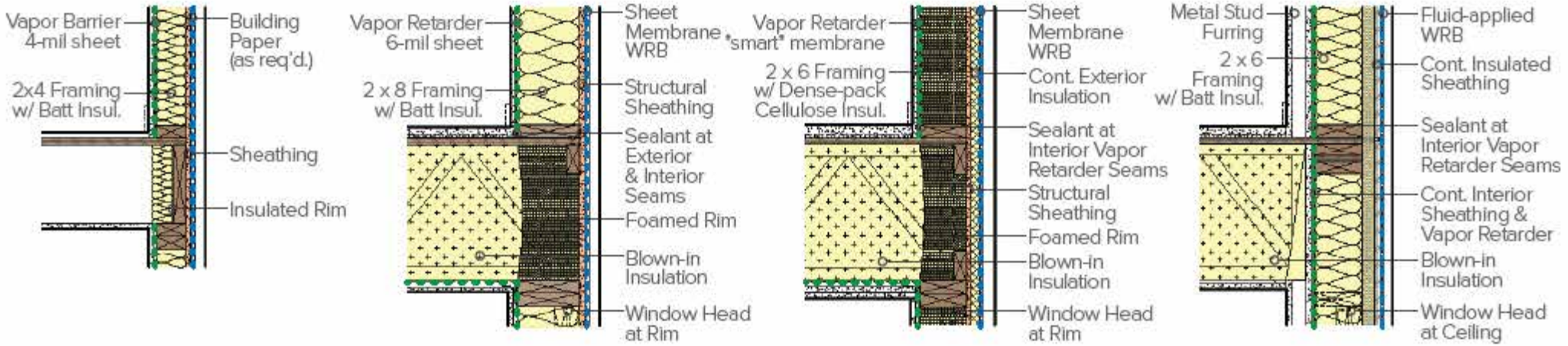
Cornerstone
ARCHITECTURAL GROUP

Takeaways for Cost Containment & Quality Control

- Source materials locally (e.g. windows)
- Train installers and site superintendents
- Simplify design and material selection
- Let trades do what they know how to build & design accordingly
- Design for “2-fers”: e.g. structure & moisture control, energy envelope & acoustics

Assembly Comparison – Climate Zone 6 & 7

TRADITIONAL WALL / RIM	TYPICAL WALL / RIM	ENHANCED WALL / RIM	INNOVATIVE WALL / RIM
Pre-1980	Current	Current	'Next-Gen'
Platform Framed	Platform Framed	Platform Framed	Balloon Framed
Building EUI: 60+ kBtu/sf	Targeted Building EUI: 40 kBtu/sf outcome	Targeted Building EUI: 30 kBtu/sf outcome	Targeted Building EUI: 20 kBtu/sf outcome



INTEGRATION OF BUILDING COMPONENTS ⟷ CONTINUITY & INTEGRITY OF MOISTURE PLANES

ROLE OF WALL / ENVELOPE

ENERGY CODE COMPLIANCE ⟷ WHOLE-BUILDING & COMPONENT MODELING

EVALUATION OF PERFORMANCE

GOALS

- Minimized Thermal Bridging
- Increased Air Tightness
- Managed Vapor Plane
- Managed Drainage Plane

Passive House

High Performance Envelope & Mechanical System

ENVELOPE

Roof Insulation	R-55
Wall Insulation	R-19 + R-9.6 CI (R-29.7 total wall assembly)
Above Parking	50 CI
Slab Insulation	R-20 CI
Awning Window	U-0.17, SHGC 0.2
Fixed Window	U-0.15, SHGC 0.27

SYSTEMS

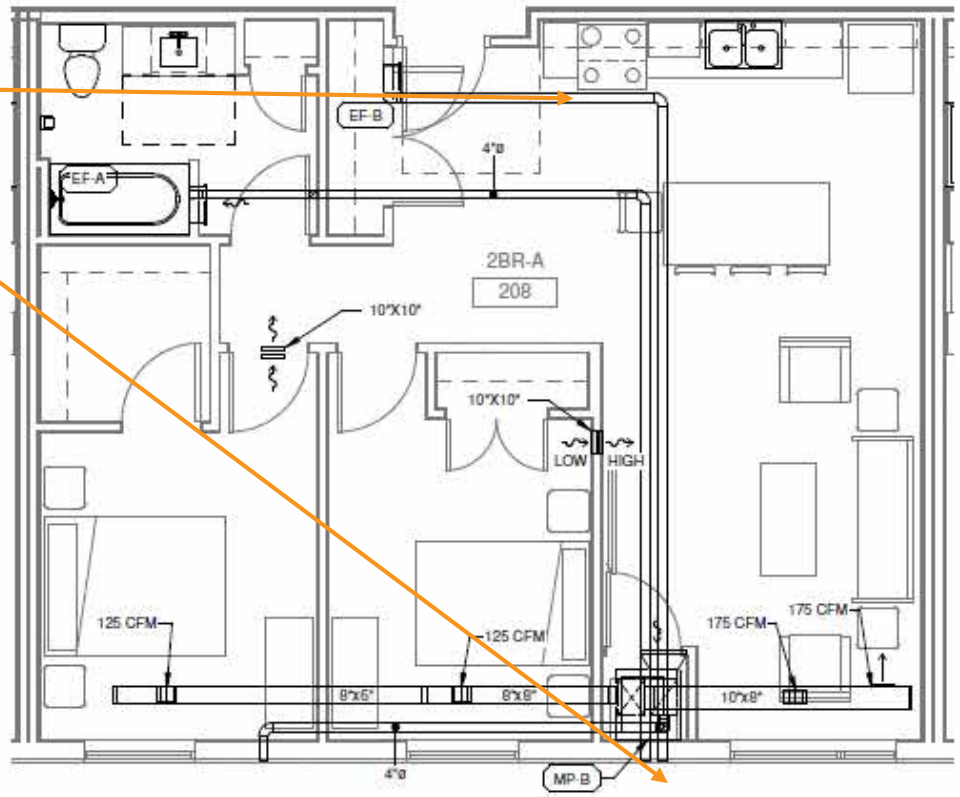
HVAC System (Cooling)	VRF with Centralized ERV
HVAC System (Heating)	Gas Fired Boilers
Dwelling HVAC Units	Fancoils (4 Pipe)
Lighting	LED
Dryers	Heat Pump mixed with Standard
DHW	Gas with VRF Preheat
Solar	40 kW system on rooftop (located on Standard House Building due to orientation)

Continuous Fresh Air Supply: Direct to Bedrooms

Standard

Direct Exhaust

Magic Pak

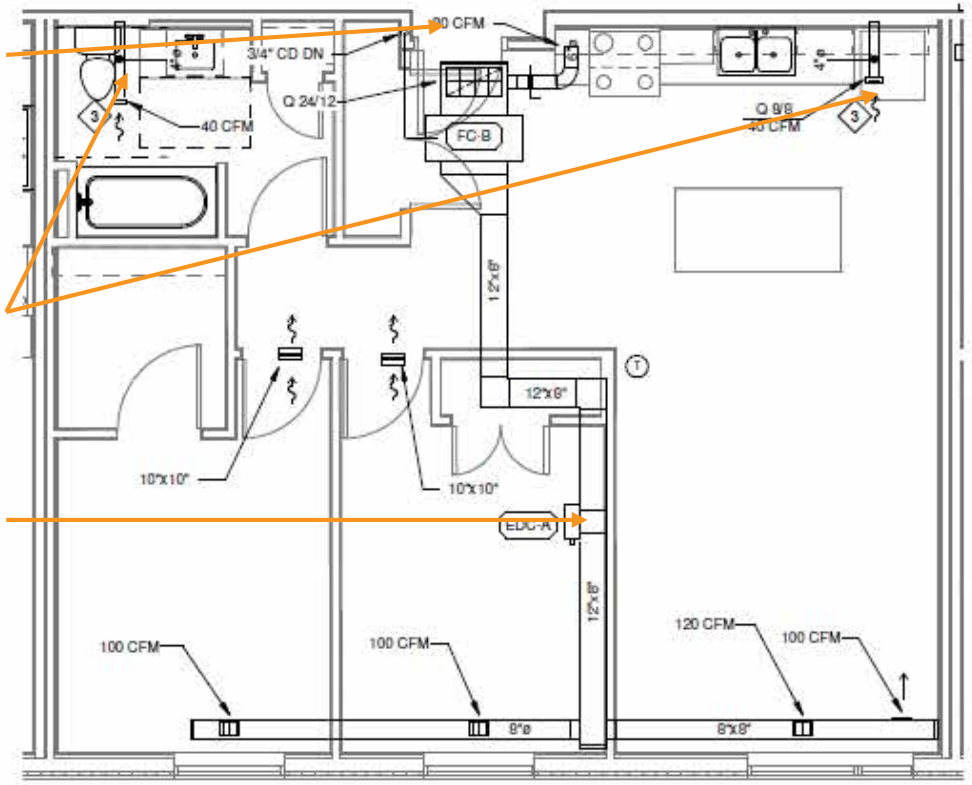


Passive House

Fan Coil

DOAS System

Electric Duct (Backup heaters)



Continuous Fresh Air Supply

Standard

Common Area Furnace

Typical Apartment Magic Pak

Passive House

Ventilation Ducts appear to be well sealed with mastic.

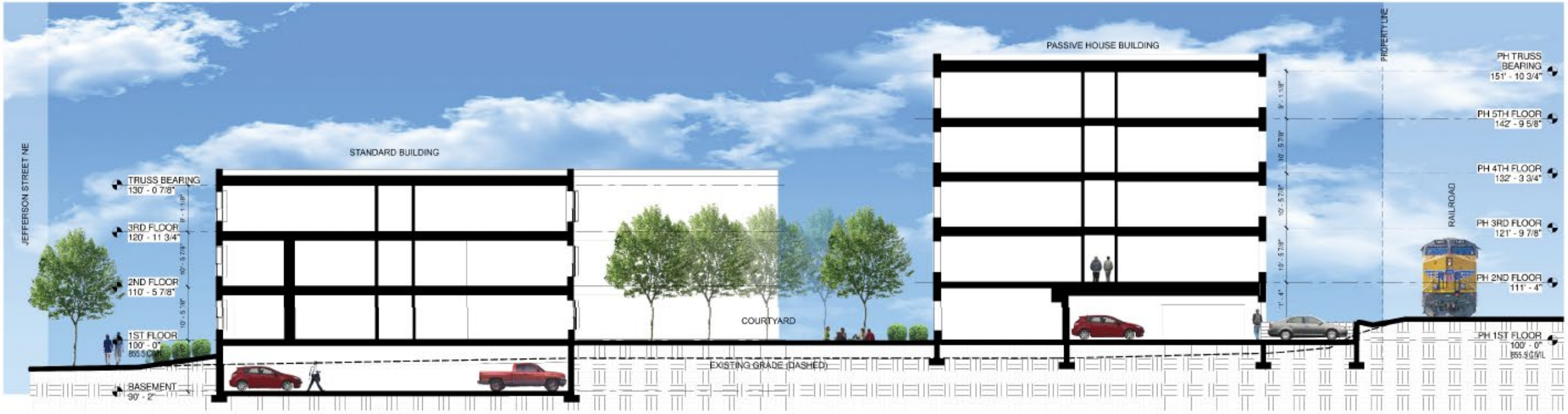
VRF Unit

DOAS Unit with Heat Recovery

Building Assemblies

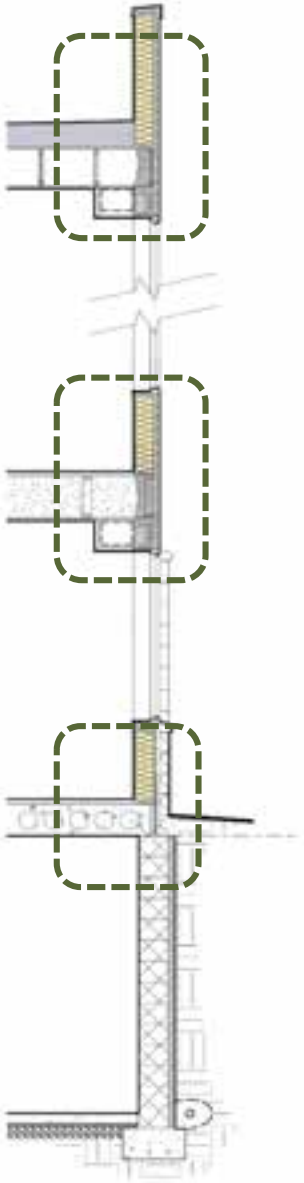
Standard Building
Roof R-Value = 49
Wall R-Value = 22
Window U-factor = .29
SHGC = .40

Passive House
Roof R-Value = 62.3
Wall R-Value = 29.7
Window U-factor = .15
SHGC = .27

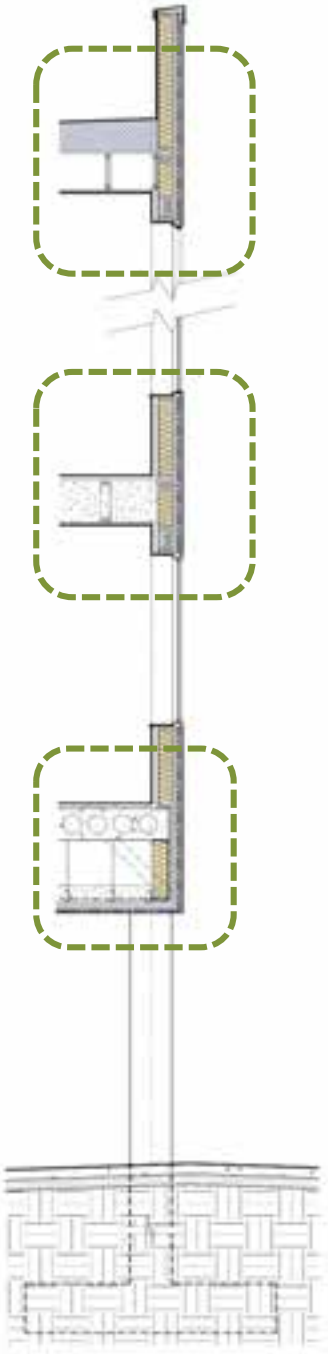


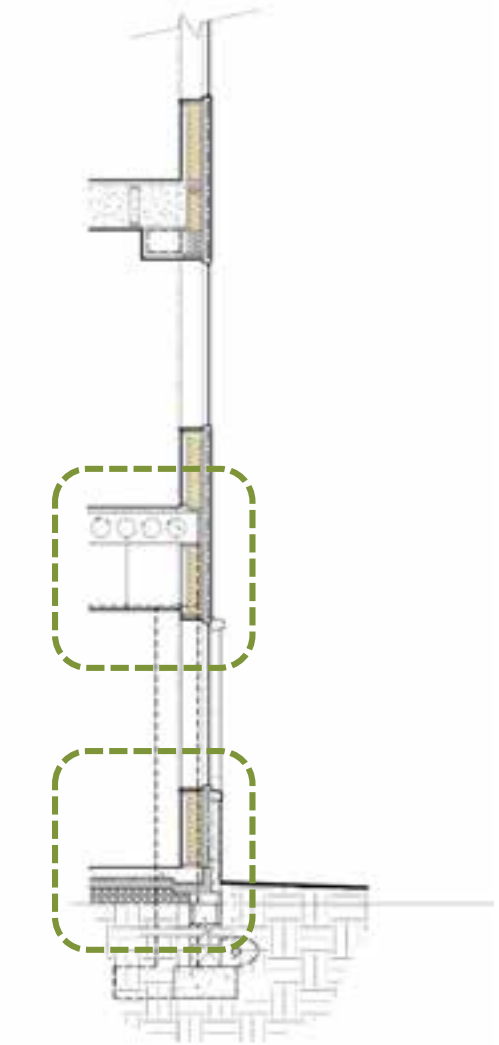
Wall Sections

Standard

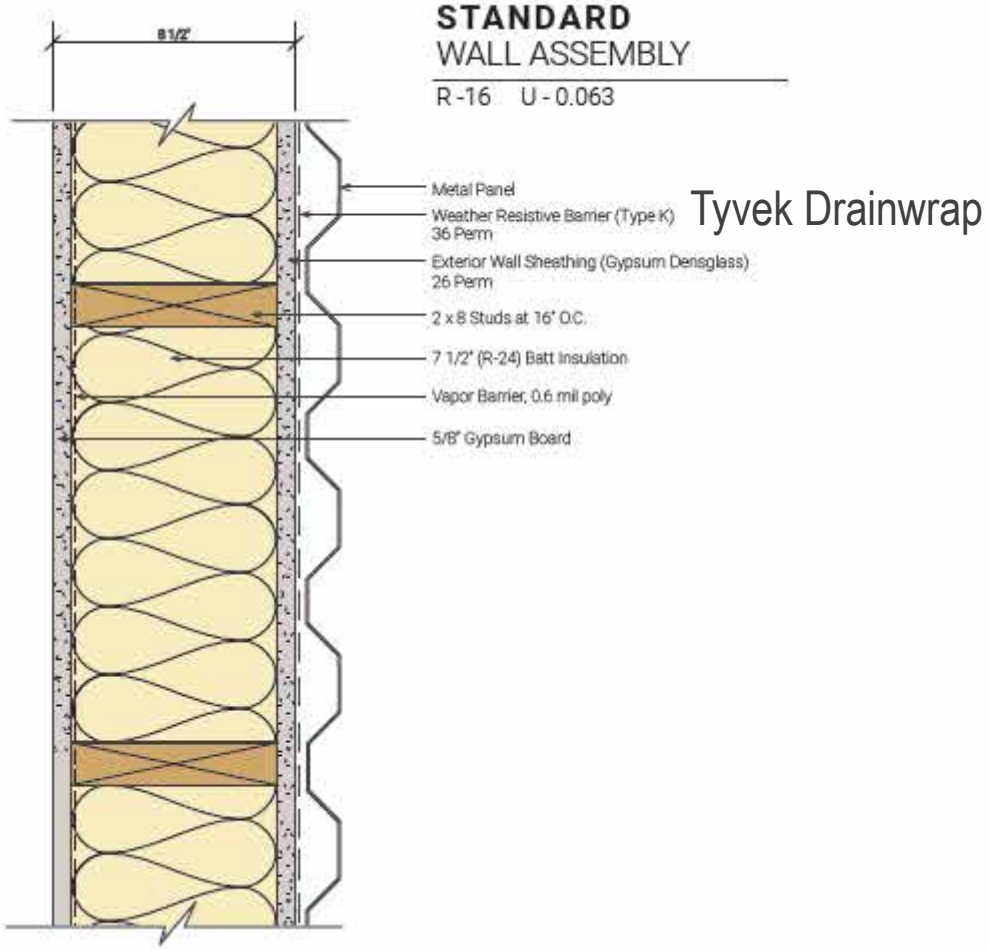


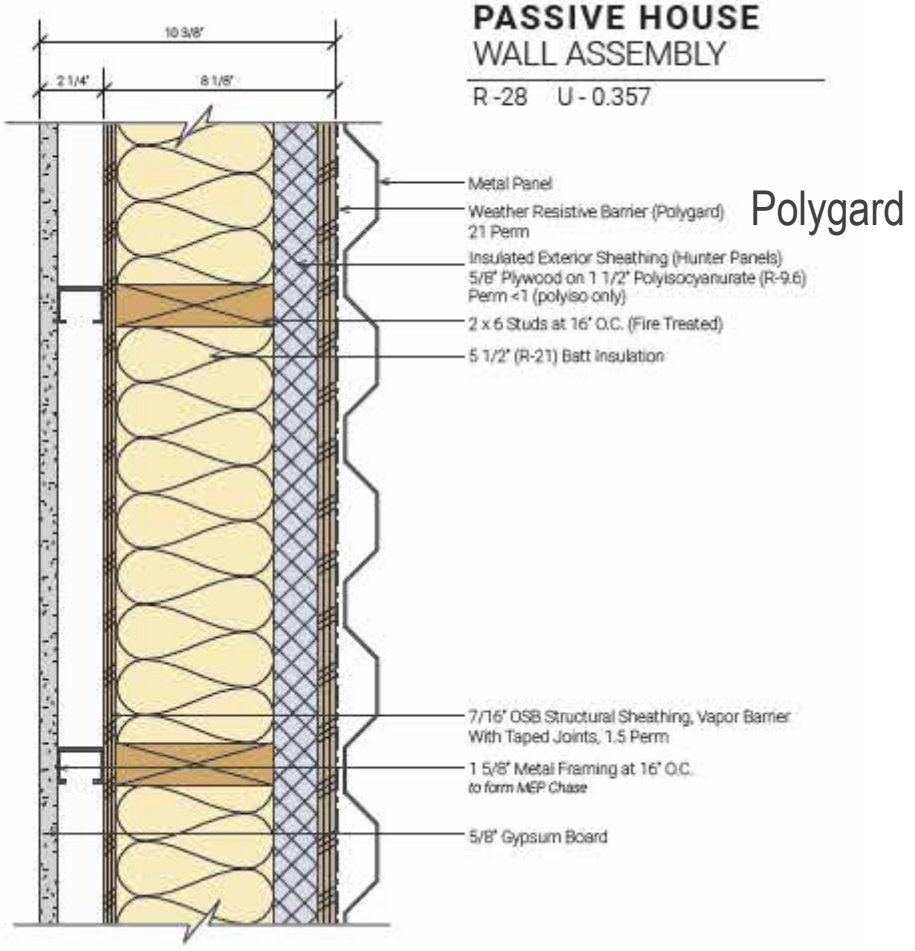
Passive House



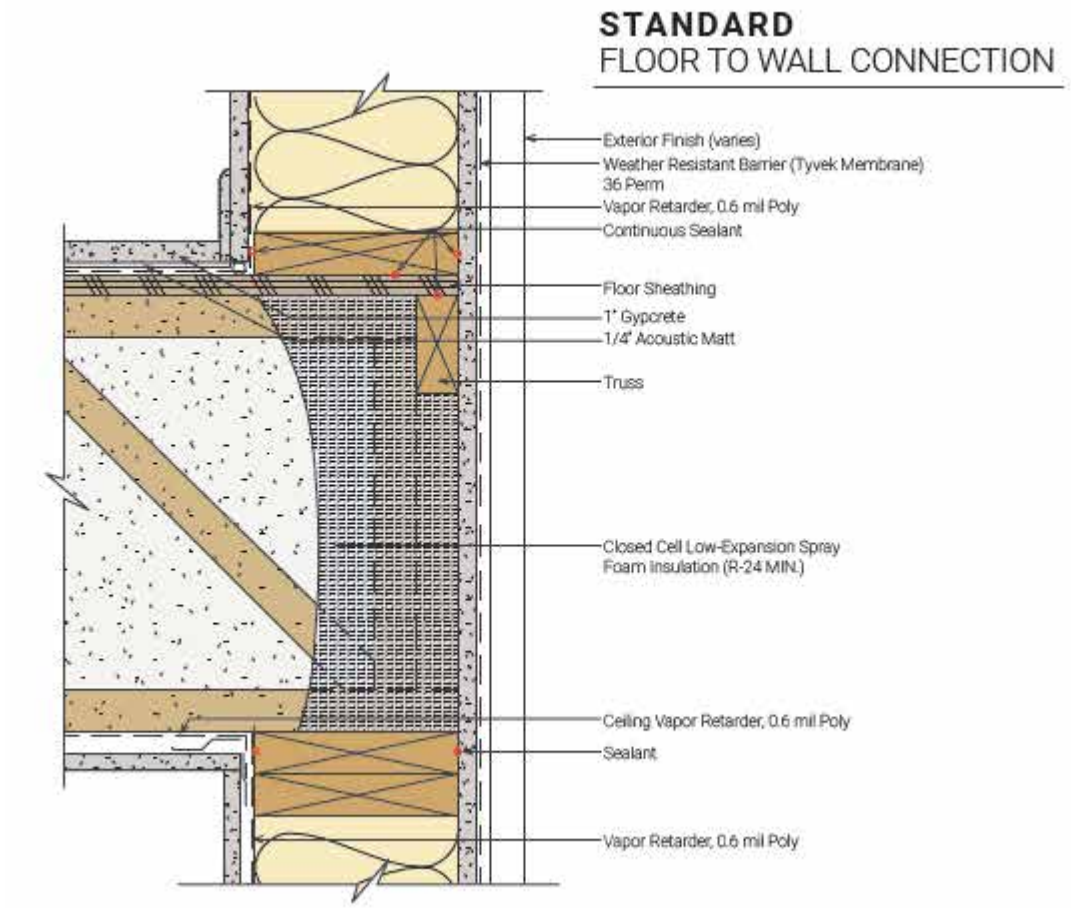


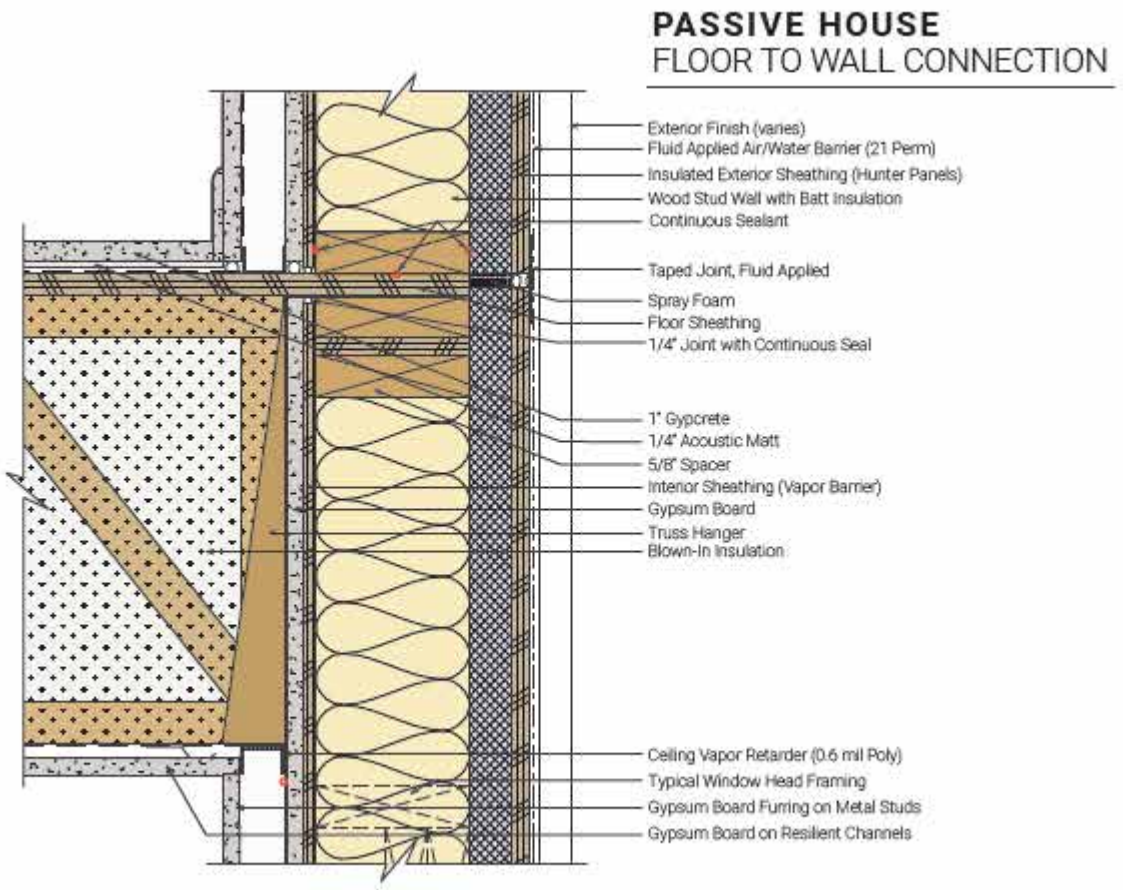
Wall Assemblies



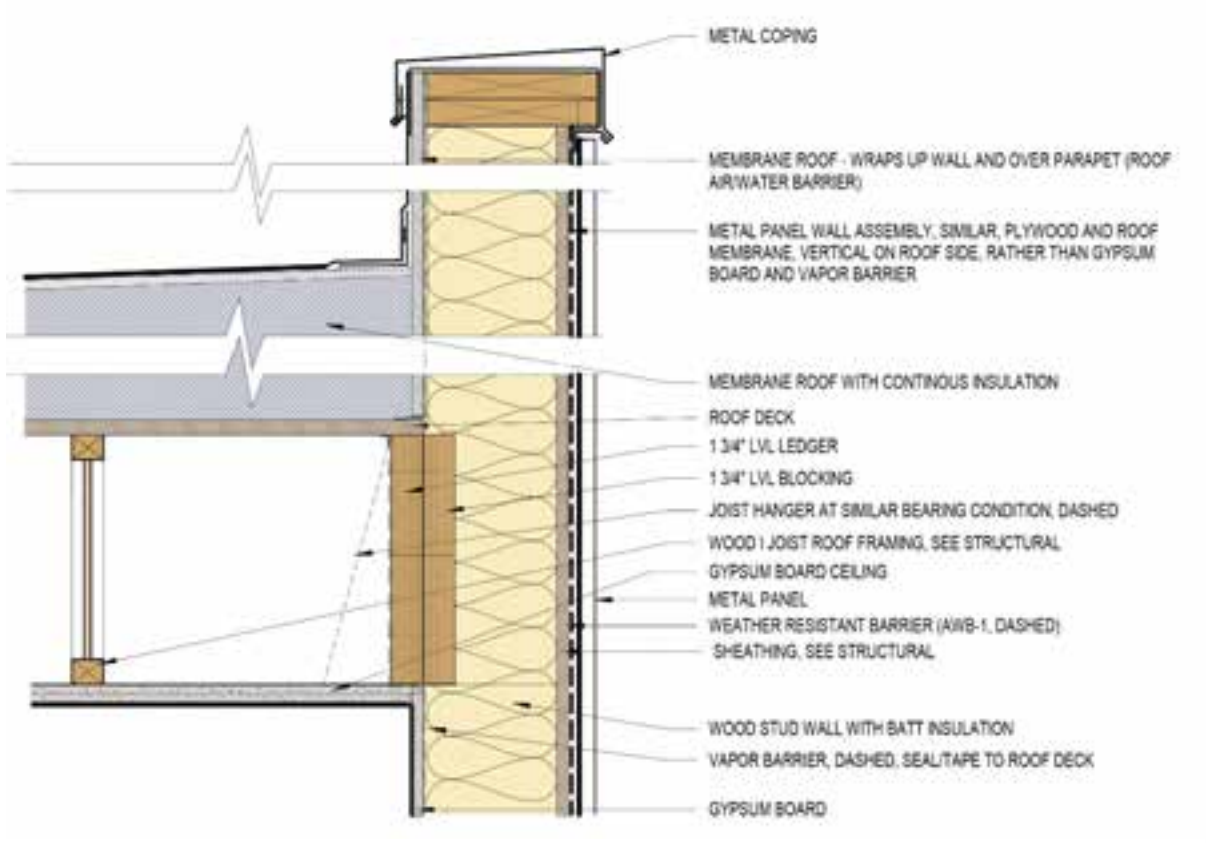


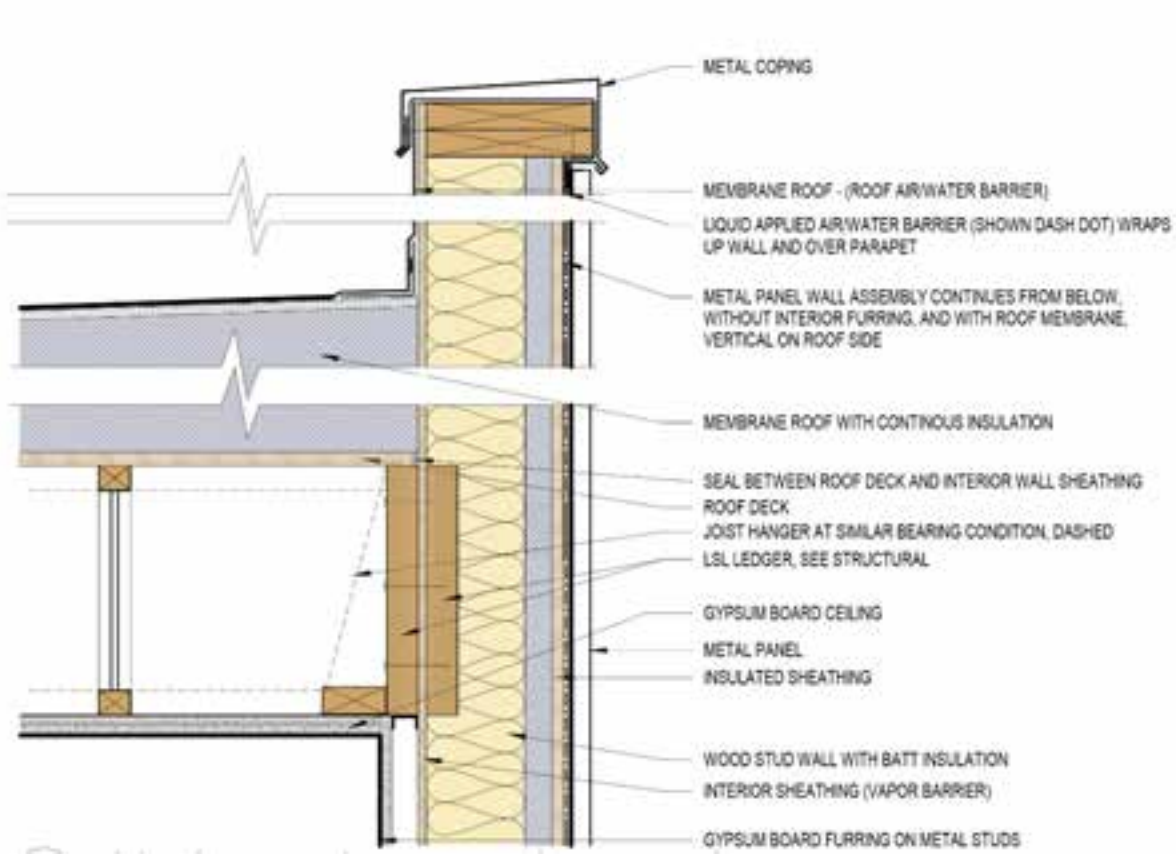
Floor to Wall Connection





Wall Details: Roof at Exterior Wall – Non-Bearing

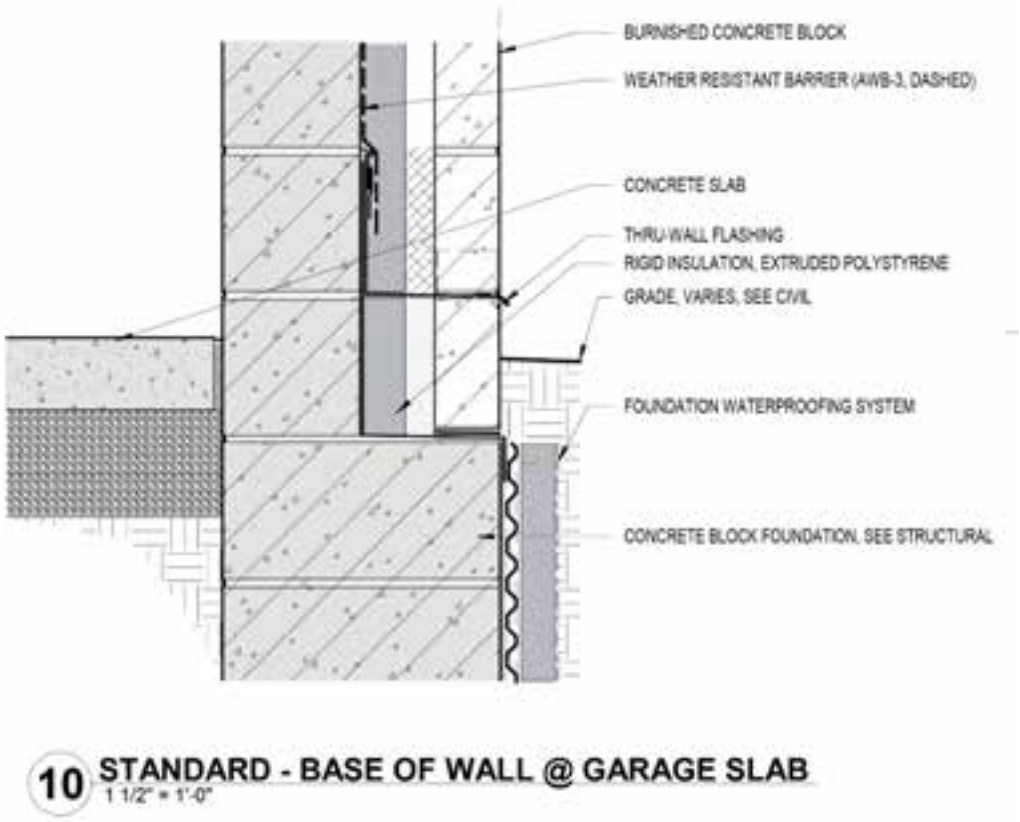




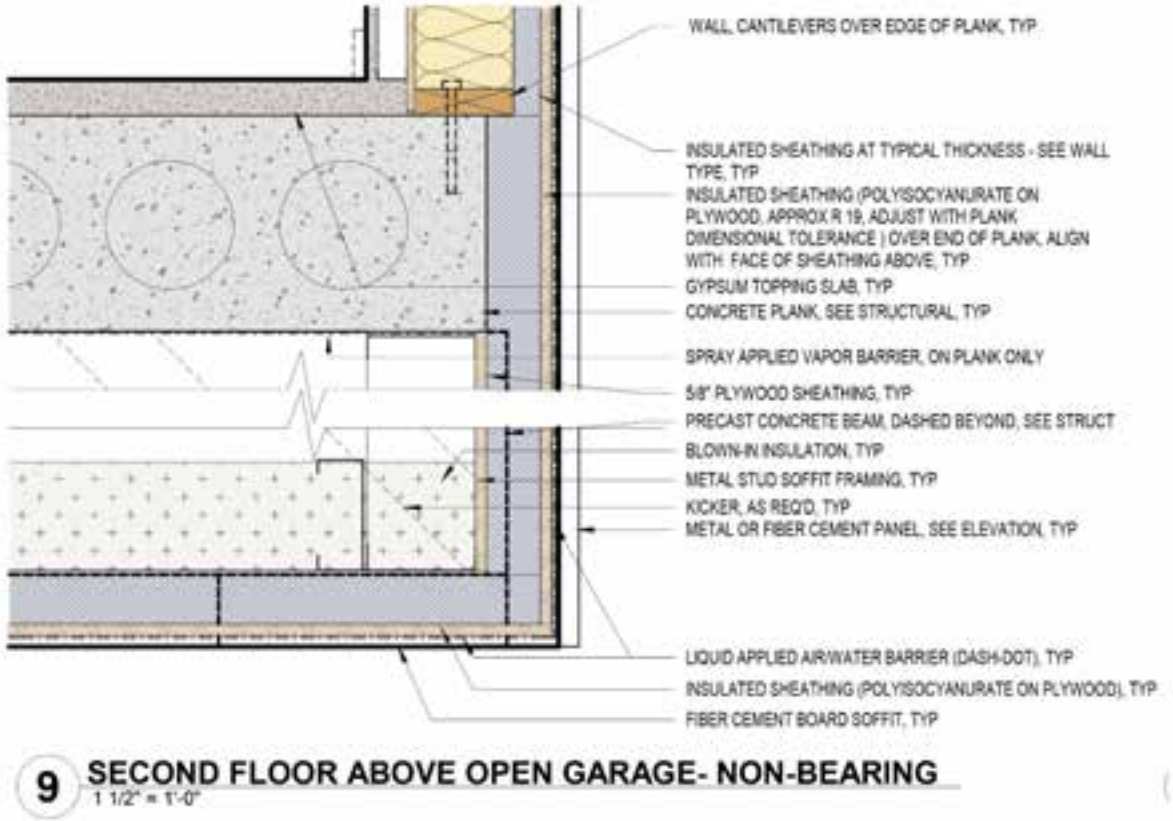
Standard

Passive House

Wall Details at Garage

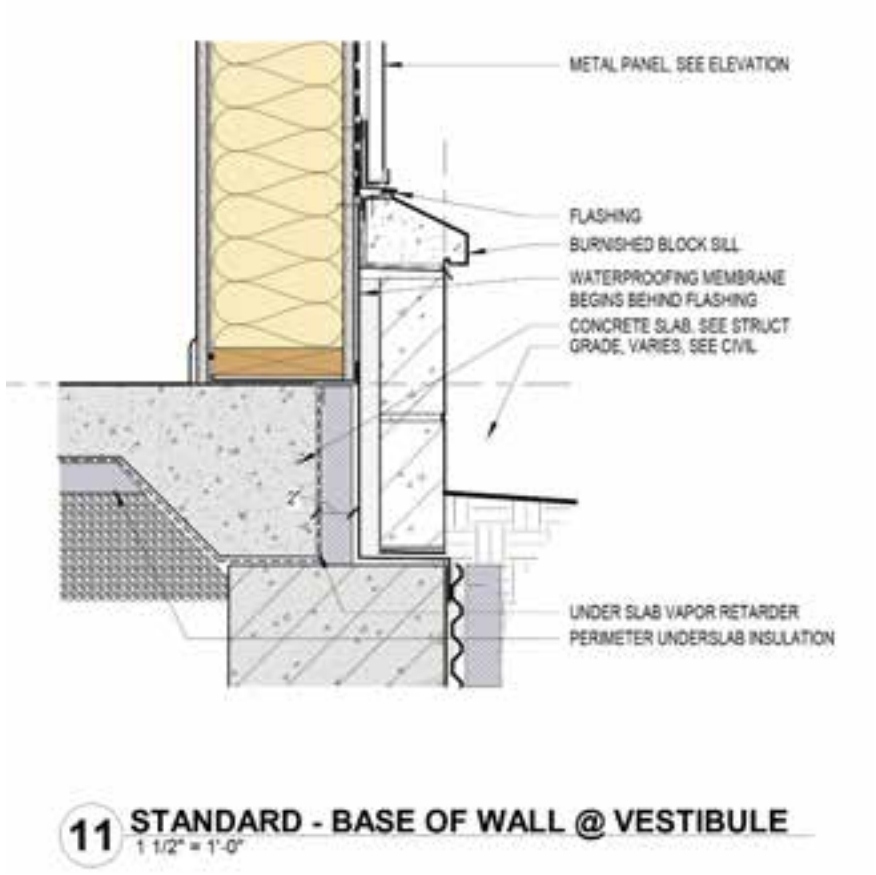


Standard

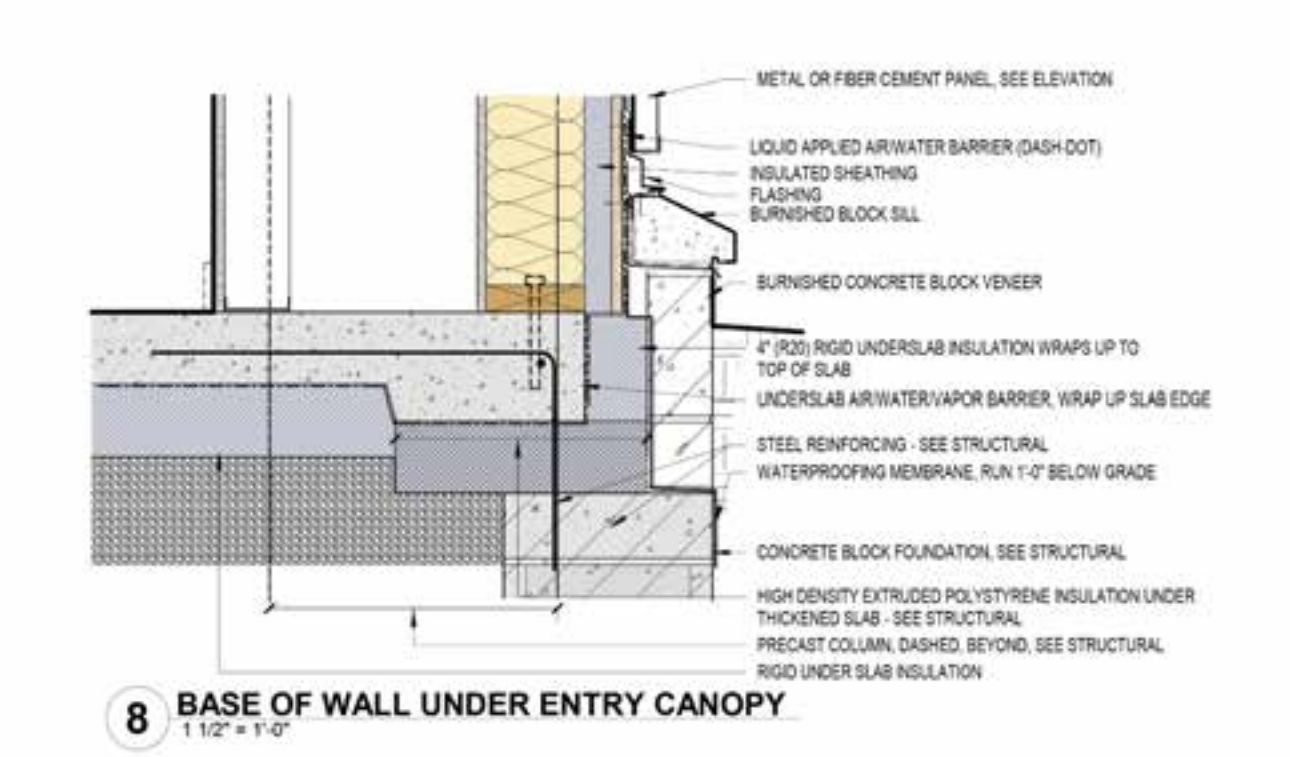


Passive House

Wall Details: Base of Wall



Standard



Passive House

Framing

Standard - Platform

Passive - Balloon

Framing: Passive House Balloon Framing

Window Openings

Standard

Passive

Insulation Cavity

Standard - Openings

Passive – No Openings

Window Openings

Standard

Passive

Gypsum Board

Standard

Passive

Framing

Standard - Platform

Passive - Balloon

Weather Barrier

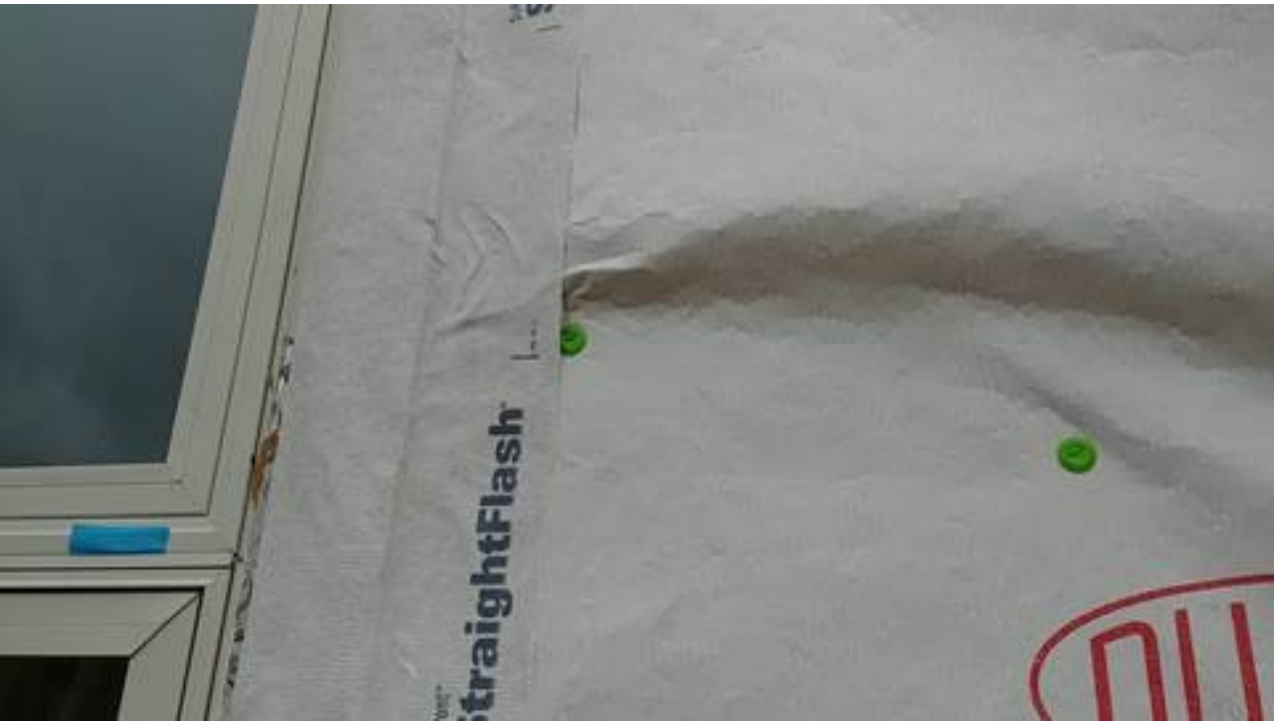
Standard - Sheet

Passive - Fluid

Passive House Fluid Vapor Barrier

Weather Barrier

Standard - Sheet



Passive - Fluid

Cladding

Standard – Rain Screen

Passive – Rain Screen

Exterior Wall Penetrations

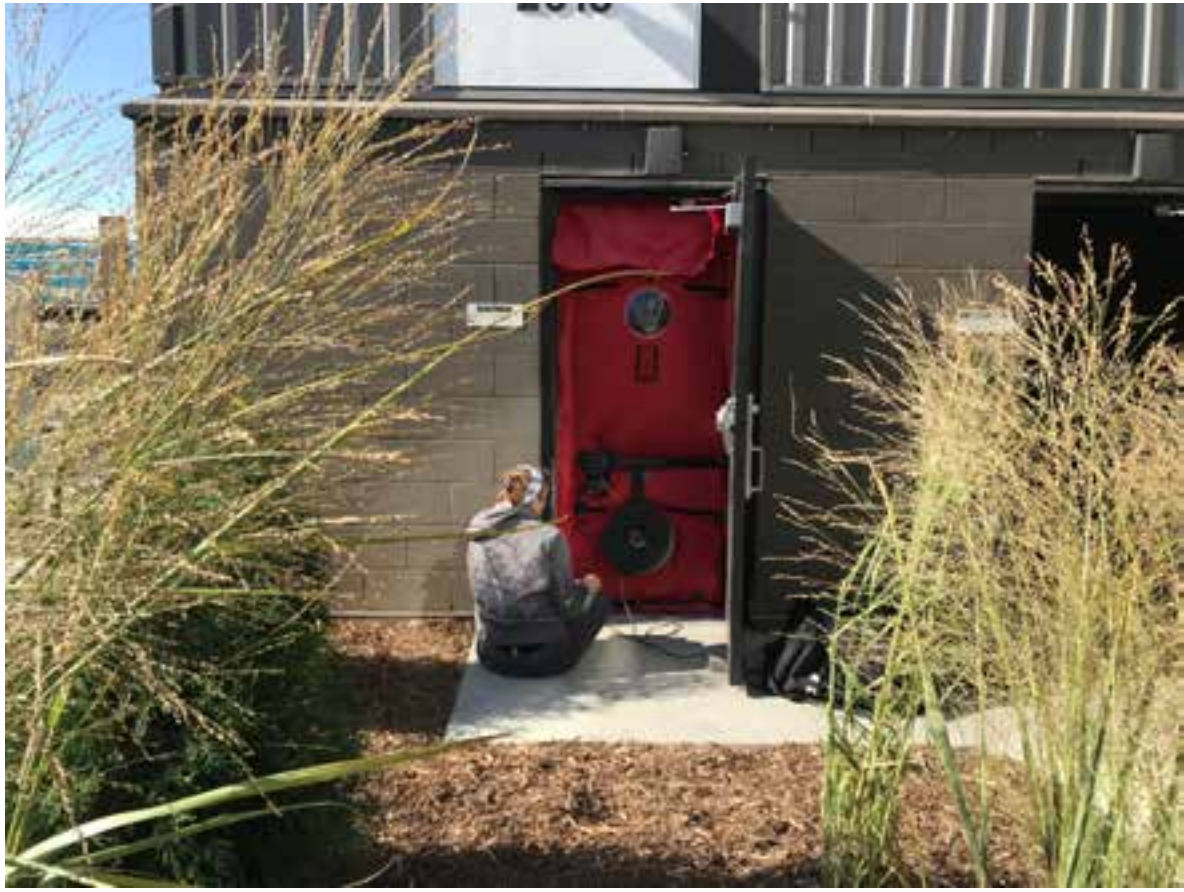
Standard

Passive

Passive House Parking Garage Ceiling

Blower Door Test Results: Passive House

Final whole building blower door test	
Square Foot of the Building Envelope	56200
Passive House Volume	420952
CFM50 test result - depressurization	2107
CFM50/Shell area	0.0375
ACH50 - depressurization	0.30
CFM50 test result - pressurization	2168
CFM50/Shell area	0.0386
ACH50 - pressurization	0.31
Average CFM50	2107
Average CFM50/Shell area	0.038
Average ACH50	0.30



Source: Final Blower Door Test Results prepared by Eco Acheivers

Energy Design Assistance: Modeling & Rebate Incentives

	Building1: Standard	Building 2: PHIUS
Percent Energy Cost Savings	30%	40%
Percent Electric Demand Savings	25%	19%
Percent Electric Consumption Savings	28%	41%
Percent Gas Consumption Savings	40%	40%
Total Incremental First Cost	$150,315	$495,724
Total Incentive	$31,806	$30319
Simple Payback with Incentive	3.1	8.6
Energy Use Intensity (EUI) (modeled)	Baseline: 79.6 KBtu/ft²/yr As Built: 51.6 KBtu/ft²/yr	Baseline: 62.8 KBtu/ft²/yr As Built: 37.7 KBtu/ft²/yr
% Savings	35%	40%

53% from Standard baseline

27% better than Standard as built

Source: Verification Reports prepared by Willdan

EDA Strategy Results: Standard Building

Space Asset Area	Strategy Description	Peak kW Savings	kWh Savings	Gas Savings (Therm)	Energy Cost Savings	Inc. Cost
Office, Garage - Enclosed, Fitness, Apartments	Lighting power reductions	14.8	65,446	-1,135	$9,316	$9,309
Apartments	ENERGY STAR APPLIANCES	3.7	28,715	103	$4,459	$21,103
Facility	Machine roomless elevator	5.2	29,141	0	$4,446	$4,229
Magic Pak	Increased DX cooling efficiency	13.7	15,482	0	$2,476	$9,127
Magic Pak	Electronically commutated motor with constant speed	1	17,454	-393	$2,421	$18,010
Apartments Common Areas Office Laundry Fitness	Glazing low solar gain, non-metal frame	3.0	-1,338	3,549	$1,962	$58,089
Garage	85% efficient gas furnace	0	0	2,307	$1,412	$191
Apartments, Garage - Enclosed, Laundry, Common Areas	Roof R 40	1	93	1,067	$675	$12,722
Apartments, Common Areas, Garage - Enclosed, Office, Laundry, Fitness	Wall R 16	0.7	333	919	$614	$1,457

EDA Strategy Results: Passive House

Space Asset Area	Strategy Description	Peak kW Savings	kWh Savings	Gas Savings (Therm)	Energy Cost Savings	Inc. Cost
HVAC	Air-cooled VRF	-21.3	160,887	0	$19,902	$94,260
Apartments, Common Areas, Laundry	Glazing low solar gain triple pane, non- metal frame	9.5	87,235	0	$10,731	$182,022
DOAS	DOAS Total heat recovery	12	55,113	0	$6,768	$47,223
Apartments, Laundry, Garage - Enclosed, Common Areas, Bike storage / Trash	Lighting Power Reduction	4.4	33,493	0	$4,305	$7,872
Apartments	ENERGY STAR Appliances	5.7	24,056	311	$3,329	$20,060
Apartments, Common Areas, Laundry, Bike Storage / Trash	Wall R 24	2.0	24,335	0	$2,996	$31,221
Facility	50% reduced air infiltration	2.4	10,012	0	$1,242	$38,159
Apartments, Common Areas, Laundry	Roof R 60	0.8	9,547	0	$1,177	$18,070
Facility	Machine roomless elevator	0.8	4,397	0	$559	$14,695
DOAS	DOAS 30% improved heat pump cooling efficiency	4	2,198	0	$294	$31,783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QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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