

Passive House Multifamily Construction

Hook & Ladder – Minneapolis, Minnesota

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



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

- Case study comparison
- Why Passive House for multifamily affordable housing?
- Review outcomes
- Compare “standard” and Passive House requirements
- Compare constructability and detailing



HOLLAND NEIGHBORHOOD



IMPROVEMENT ASSOCIATION

- Art
- Energy
- Innovation



After



Before



PHIUS+ 2015 REQUIREMENTS

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



OCCUPANT BENEFITS

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



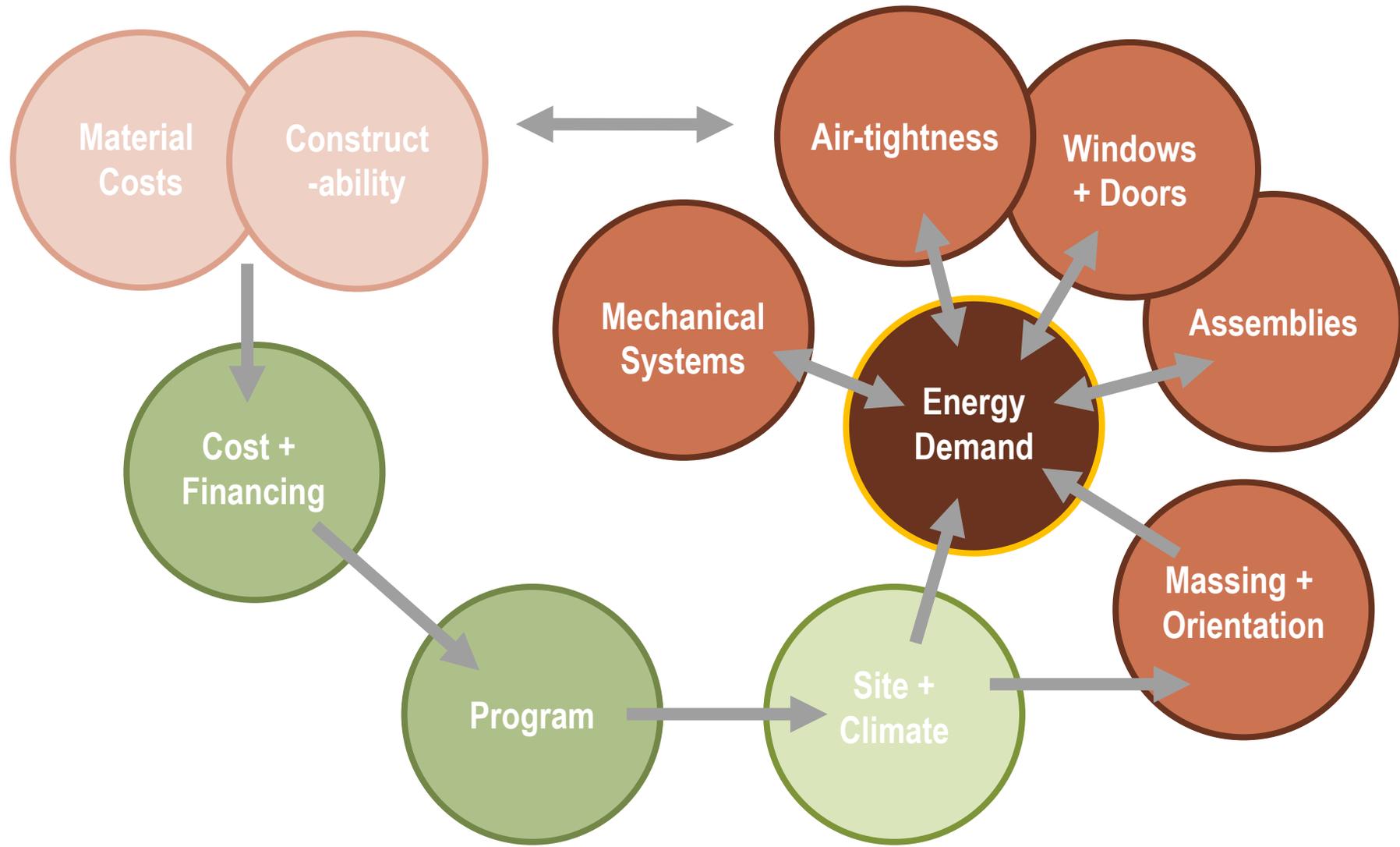
COMMUNITY BENEFITS

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

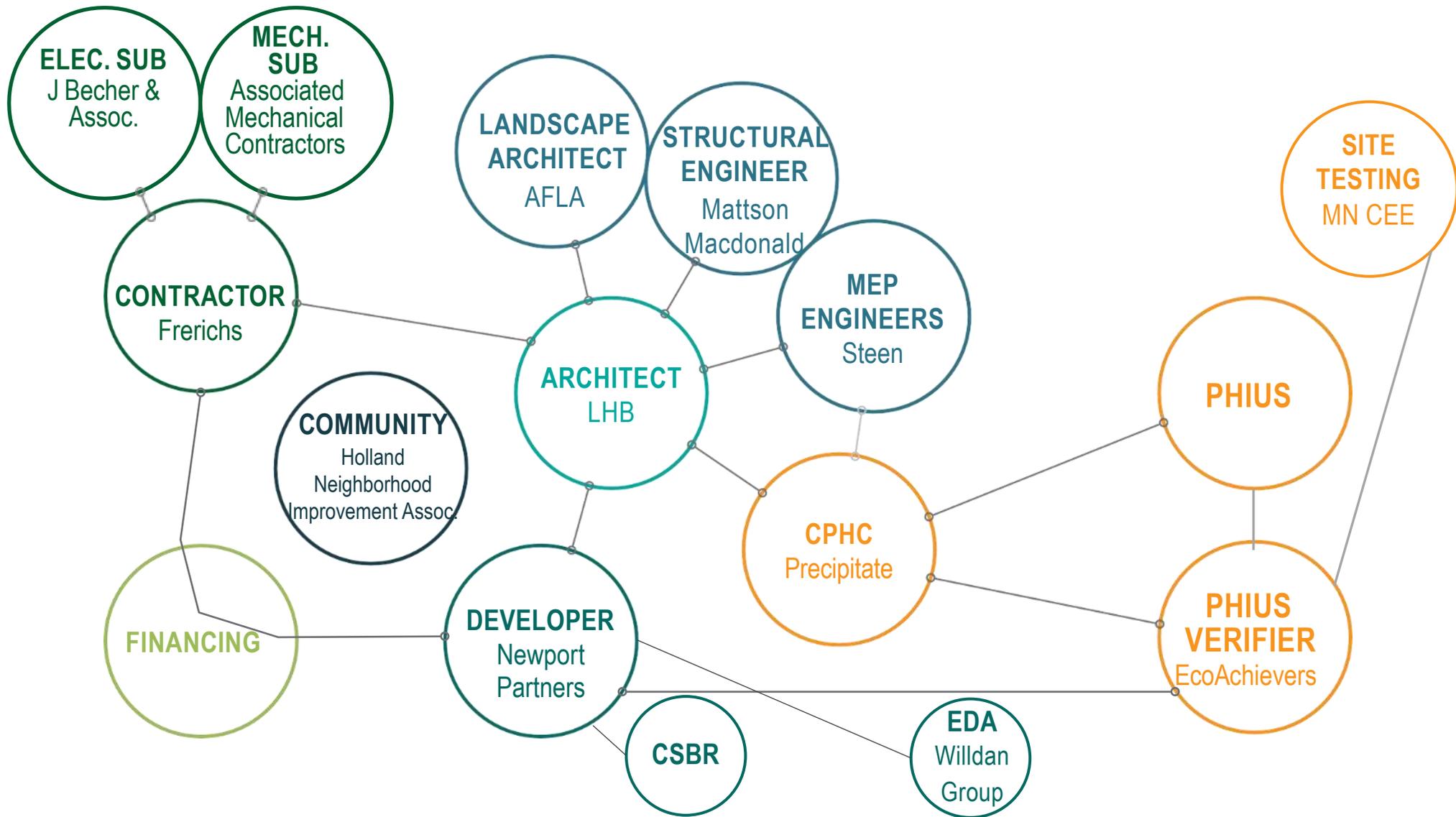


OWNER BENEFITS

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



INTEGRATED DESIGN



DEVELOPMENT TEAM RELATIONSHIPS

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

STRUCTURAL ENGINEERING: MATTSON MACDONALD YOUNG

- Kirk Davis, Structural Engineer

MECHANICAL & ELECTRICAL ENGINEERING: STEEN ENGINEERING

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

CIVIL ENGINEERING : WENCK ASSOCIATES

- Roshan Grieme, Civil Engineer

LANDSCAPE ARCHITECTS:

AUNE FERNANDEZ LANDSCAPE ARCHITECTURE

- Jason Aune, Landscape Architect

GENERAL 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

PROJECT TEAM

PASSIVE HOUSE PRINCIPLES

Minimize Thermal Loss/Gain

- Continuous Insulation
- Minimize thermal bridging

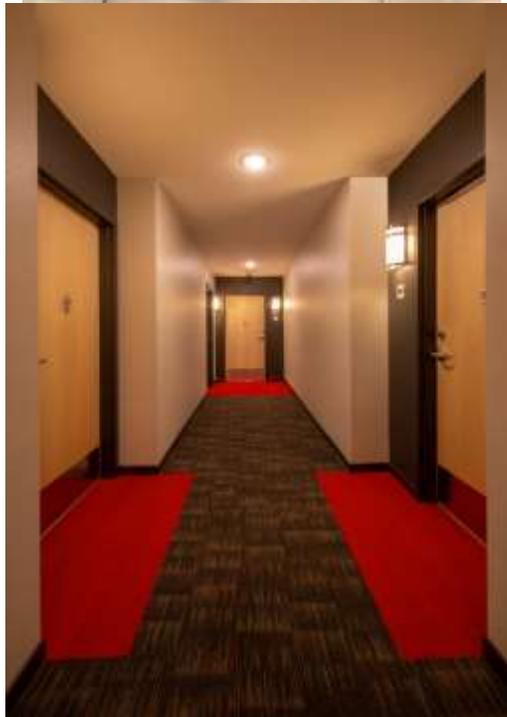
Air-Tight Construction

- Proper location and durability of air barrier and vapor retarder

High Performance Windows/Doors

Balanced Ventilation (ERV)

Minimized Space Conditioning



PHIUS CERTIFICATION

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



**Building 1: Standard
Construction Type VB**

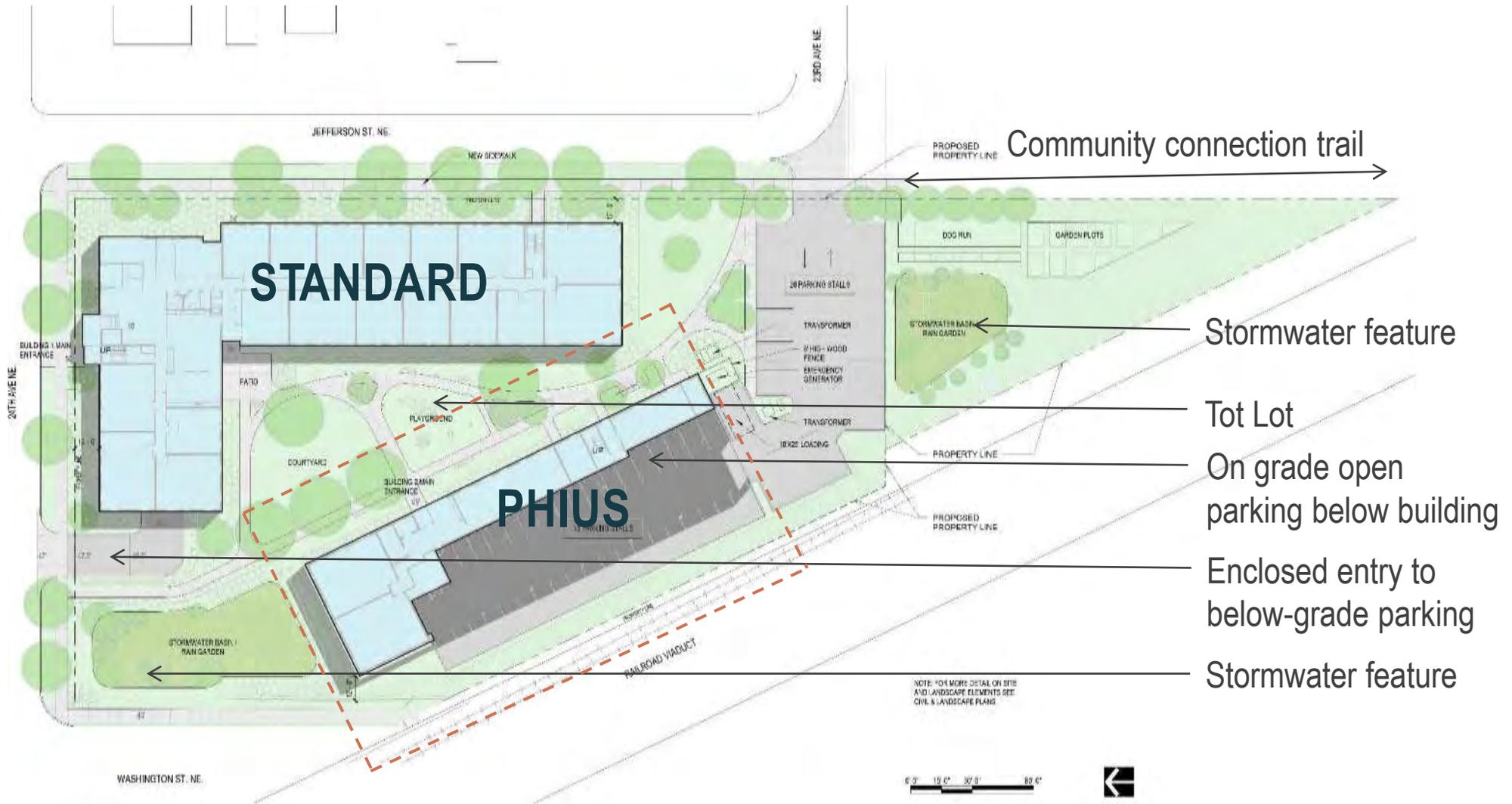
- 59 Units (32-1BR, 16-2BR, 11-3BR)
- 3-story wood frame over 1 level precast
- 46,595 net rentable SF
- 59,553 GSF finished
- 19,768 GSF enclosed parking below

**Building 2: Passive House
Construction Type VA**

- 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

PROJECT STATISTICS



STANDARD BUILDING

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

PHIUS

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

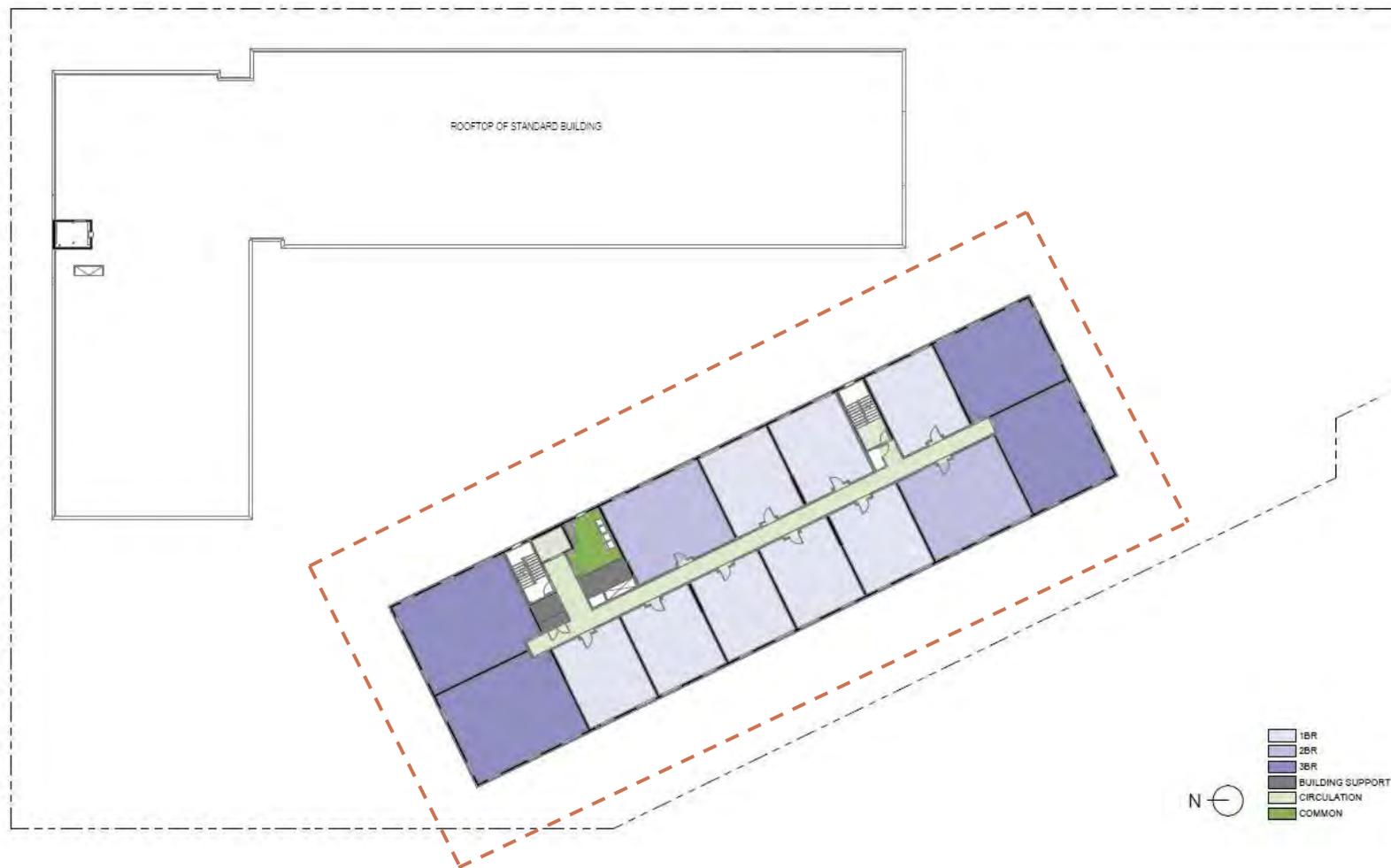
PROJECT SITE



FIRST FLOOR



SECOND & THIRD FLOORS



FOURTH & FIFTH FLOORS

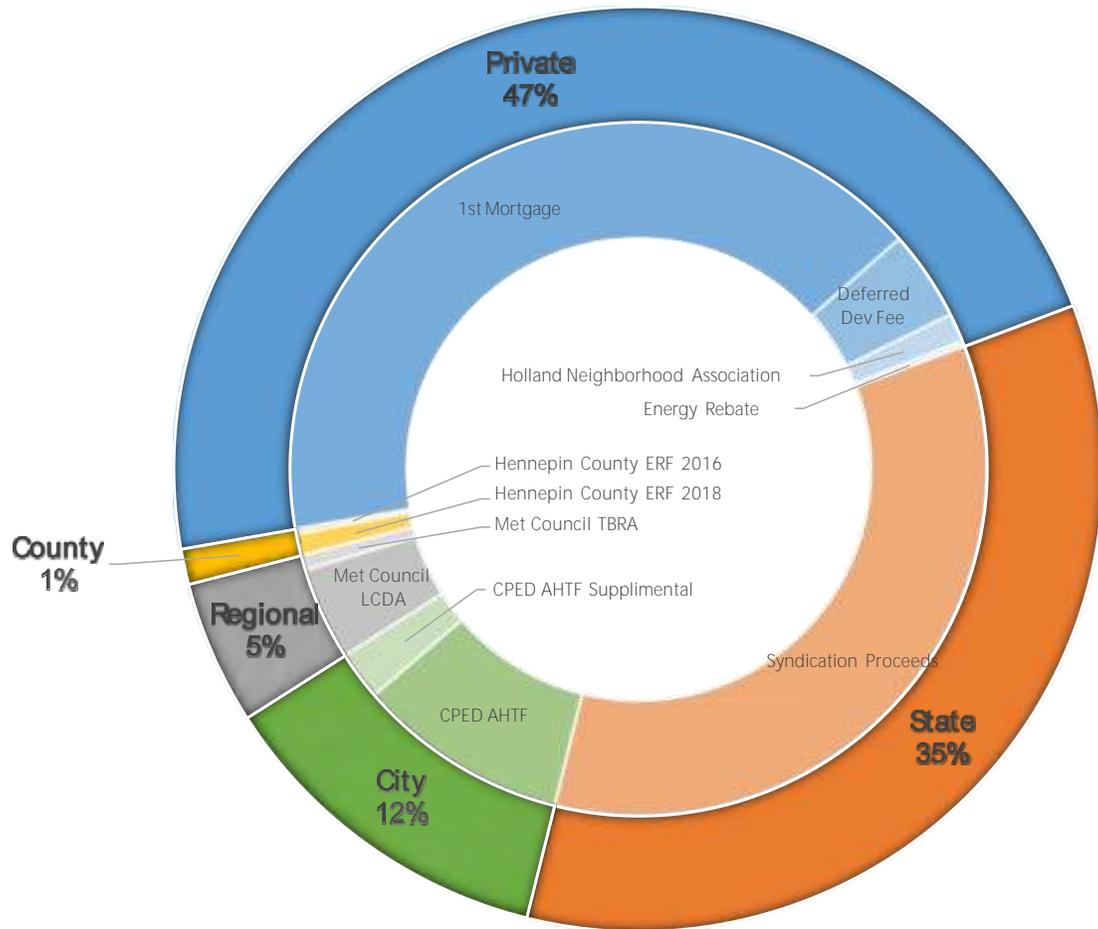


<i>ENERGY USE INTENSITY (EUI = kBtu/sf/yr)</i>		
	Standard Building (with enclosed parking)	Passive House Building (without enclosed parking)
EUI Baseline	75.4	66.7
EUI Goal	62.3	40
EUI Predicted	56.7	23.75

Standard Building HERS Rating: 61 Target, 51 Actual

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

OUTCOME



TOTAL COST (Excluding site)

PHIUS BUILDING

\$10,020,951 = \$149.20/GSF w/ parking

\$163.53 GSF w/o parking

STANDARD BUILDING

\$9,547,675 = \$120.37/GSF w/ parking

\$140.41/GSF w/o parking

	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)

Thermal and Moisture Protection / Window Openings

DESIGN PERFORMANCE STANDARDS



PRECEDENT : VANCOUVER – ENVELOPE & CONSTRUCTABILITY

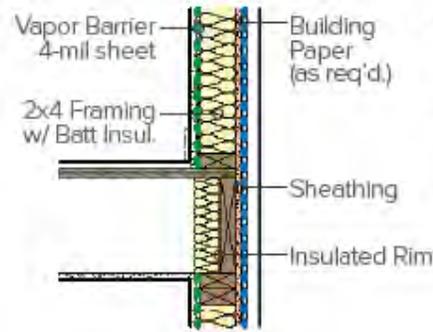
- Source materials locally (e.g. windows)
- Train installers and site superintendents
- Simplify design and material selection
- Let trades do what they know how to build & design accordingly
- Design for “2-fers”: e.g. structure & moisture control, energy envelope & acoustics



TAKEAWAYS FOR COST CONTAINMENT AND QUALITY CONTROL

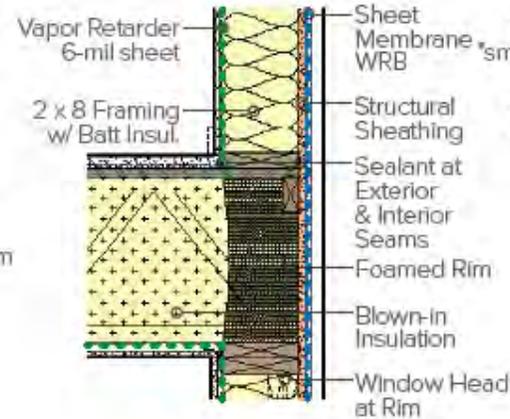
TRADITIONAL WALL / RIM

Pre-1980
Platform Framed
Building EUI:
60+ kBtu/sf



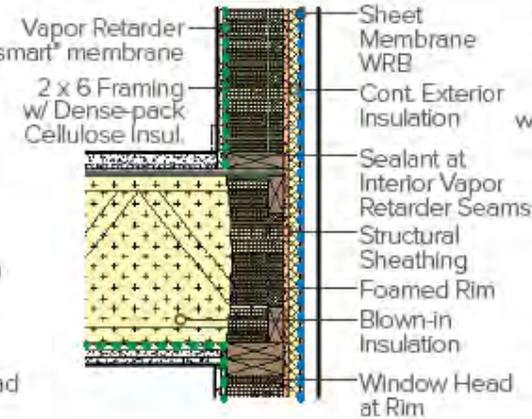
TYPICAL WALL / RIM

Current
Platform Framed
Targeted Building EUI: 40
kBtu/sf outcome



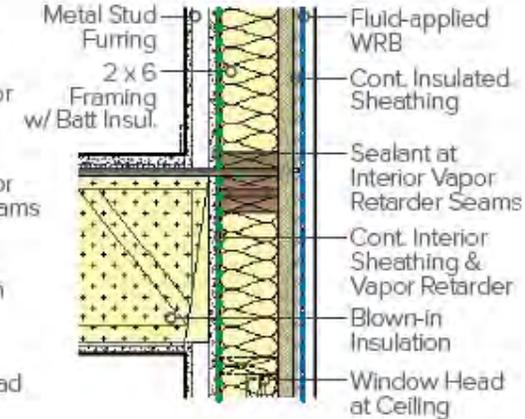
ENHANCED WALL / RIM

Current
Platform Framed
Targeted Building EUI: 30
kBtu/sf outcome



INNOVATIVE WALL / RIM

'Next-Gen'
Balloon Framed
Targeted Building EUI: 20
kBtu/sf outcome



GOALS

- Minimalized thermal bridging
- Increased air tightness
- Managed vapor plane
- Managed drainage plane

INTEGRATION OF BUILDING COMPONENTS

CONTINUITY & INTEGRITY OF MOISTURE PLANES

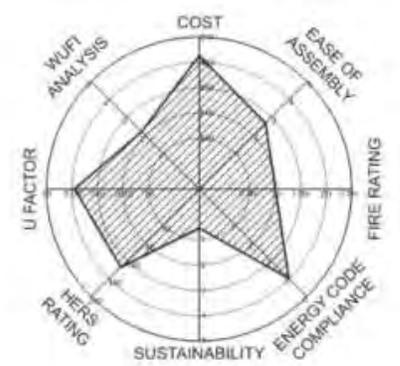
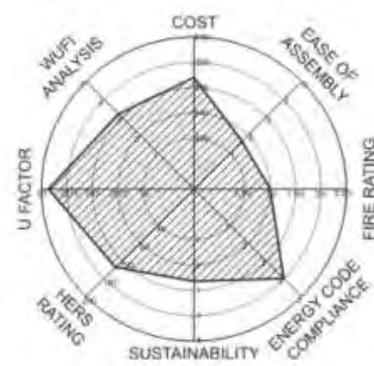
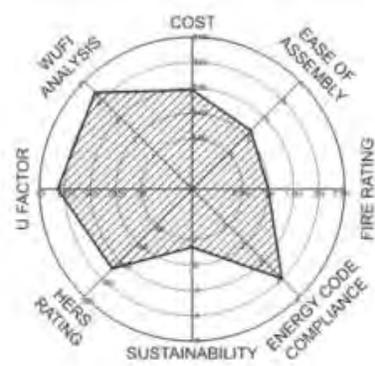
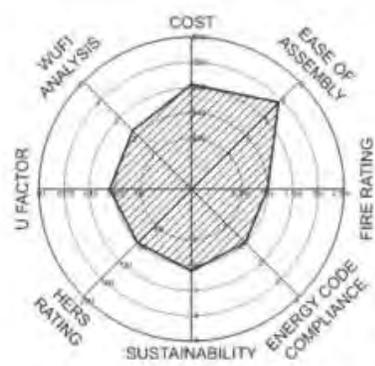
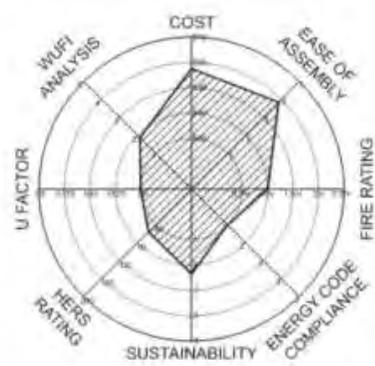
ROLE OF WALL / ENVELOPE

ENERGY CODE COMPLIANCE

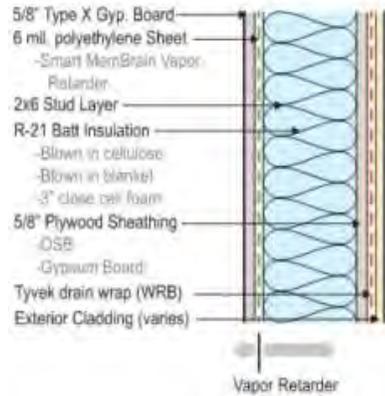
WHOLE-BUILDING & COMPONENT MODELING

EVALUATION OF PERFORMANCE

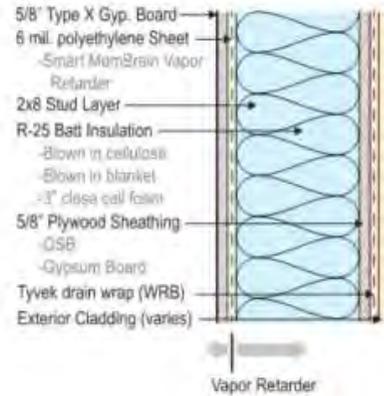
ASSEMBLY COMPARISON : CLIMATE ZONE 6 & 7



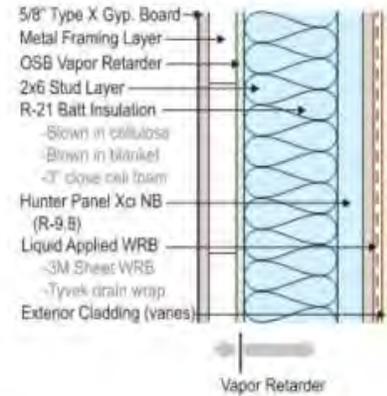
STANDARD 2X6 WALL



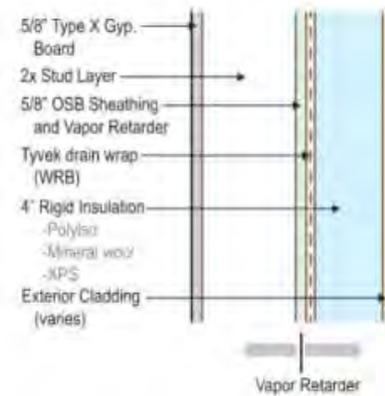
STANDARD 2X8 WALL



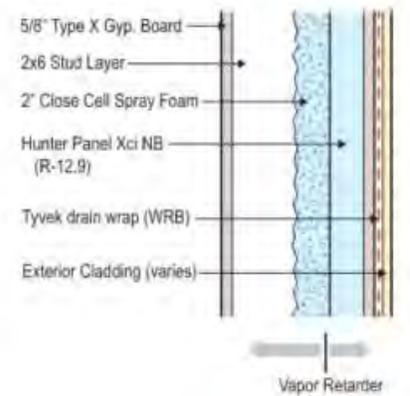
PASSIVE HOUSE WALL



THE PERFECT WALL



AWESOME WALL



Base Cost: \$/SF				
Carbon Footprint:				
.060 U Factor	.051 U Factor	.035 U Factor	.033 U Factor	.038 U Factor
HERS Rating:				
WUFI Analysis:				
Fire Rating:				
Energy Code:				

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 w/ standard
DHW - Gas with VRF Preheat
Solar - 40 kW system on rooftop
(located on Standard Building due to orientation)

ENVELOPE

Roof Insulation	R-55
Wall Insulation (R-29.7 total wall assembly)	R-19 + R-9.6 CI
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



Common Area Furnace



VRF Unit

Standard



Typical Apartment Magic Pak

Passive House



Ventilation Ducts appear to be well sealed with mastic.



DOAS Unit with Heat Recovery

CONTINUOUS FRESH AIR SUPPLY



Standard Building

Roof R-Value = 49

Wall R-Value = 22

Window U-factor = .29

SHGC = .40

Passive House

Roof R-Value = 62.3

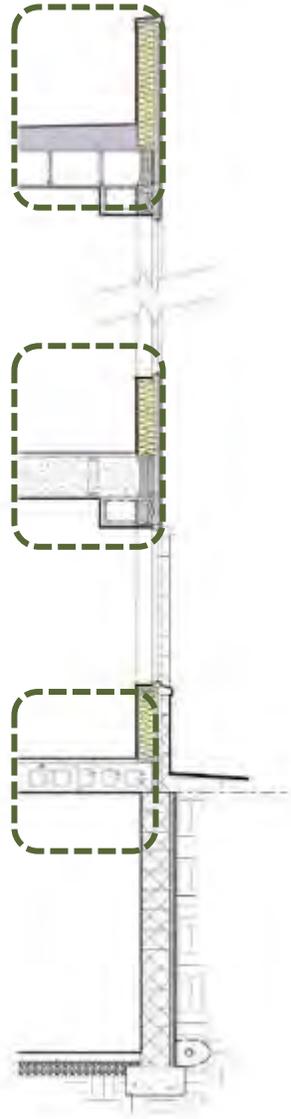
Wall R-Value = 29.7

Window U-factor = .15

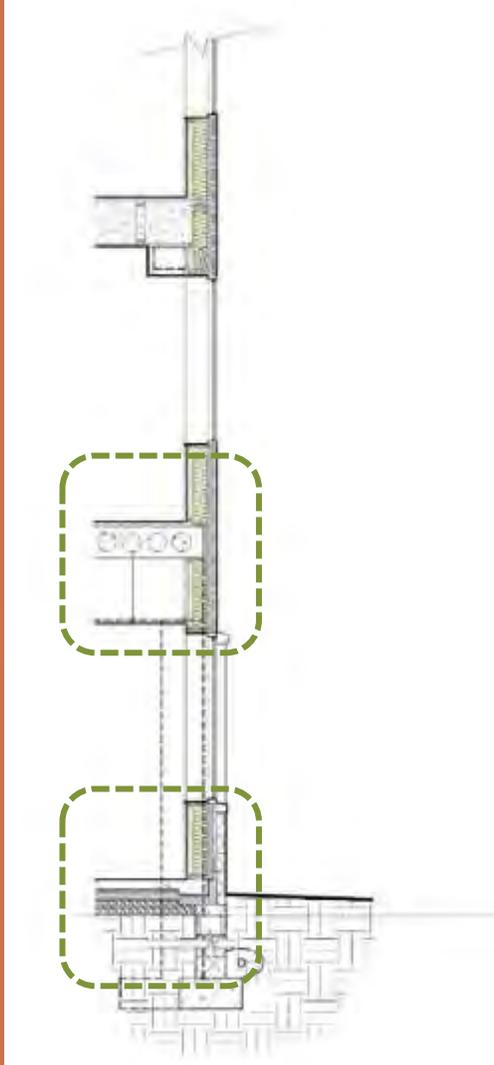
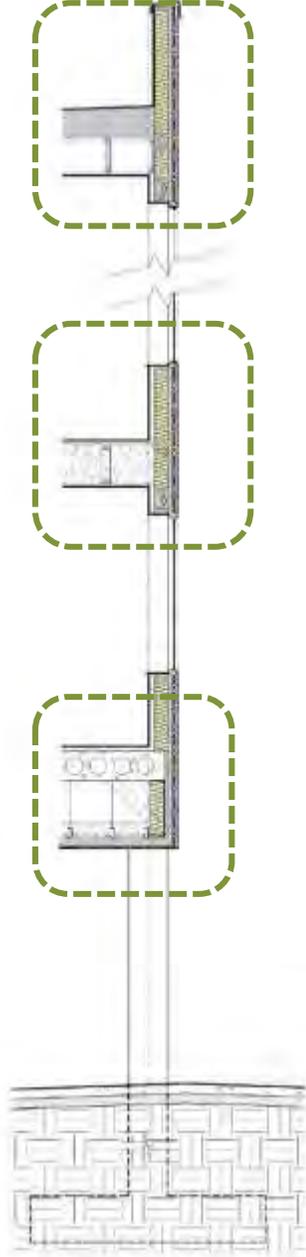
SHGC = .27

BUILDING ASSEMBLIES

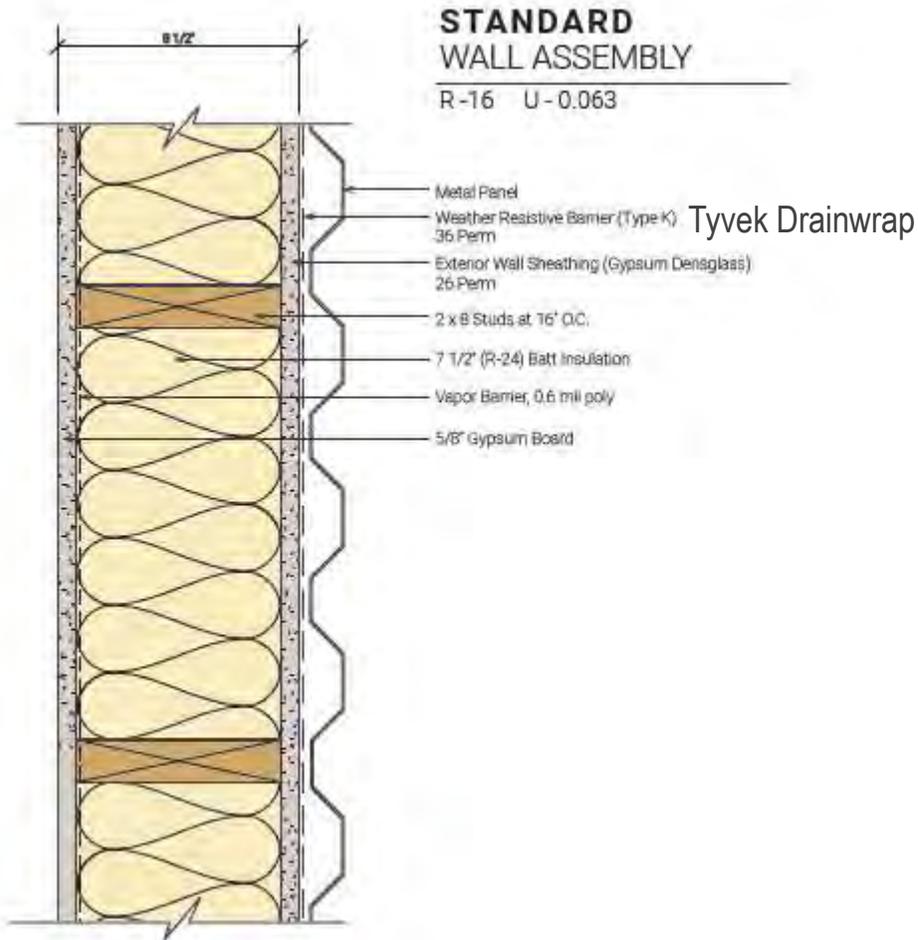
Standard



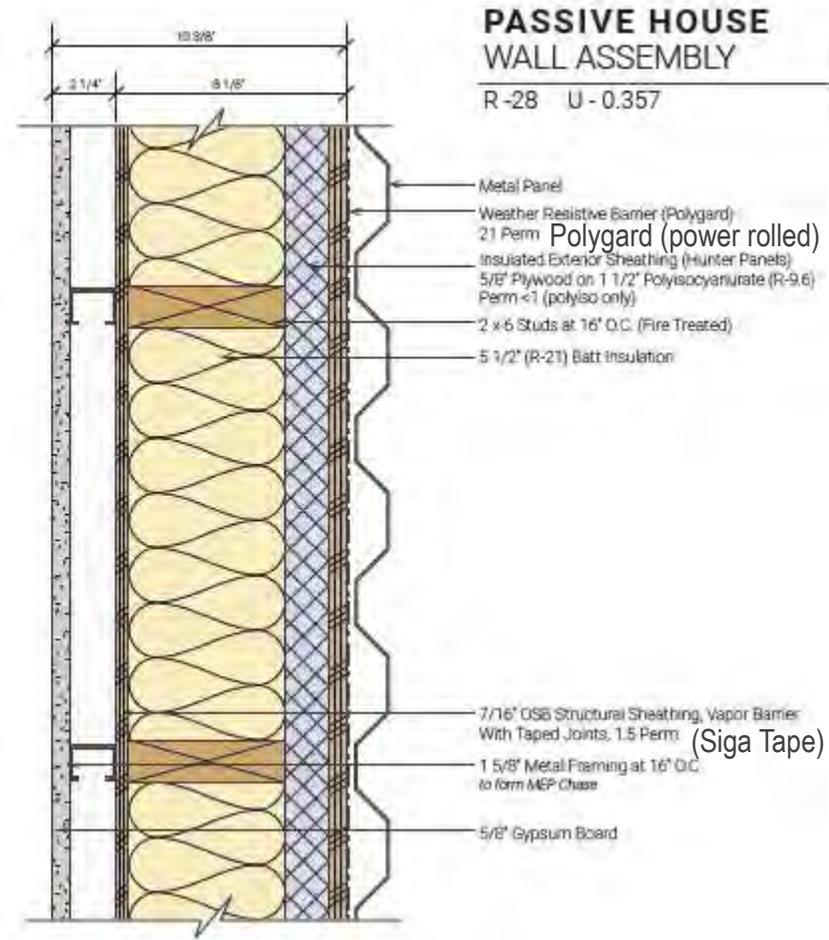
Passive House



WALL SECTIONS



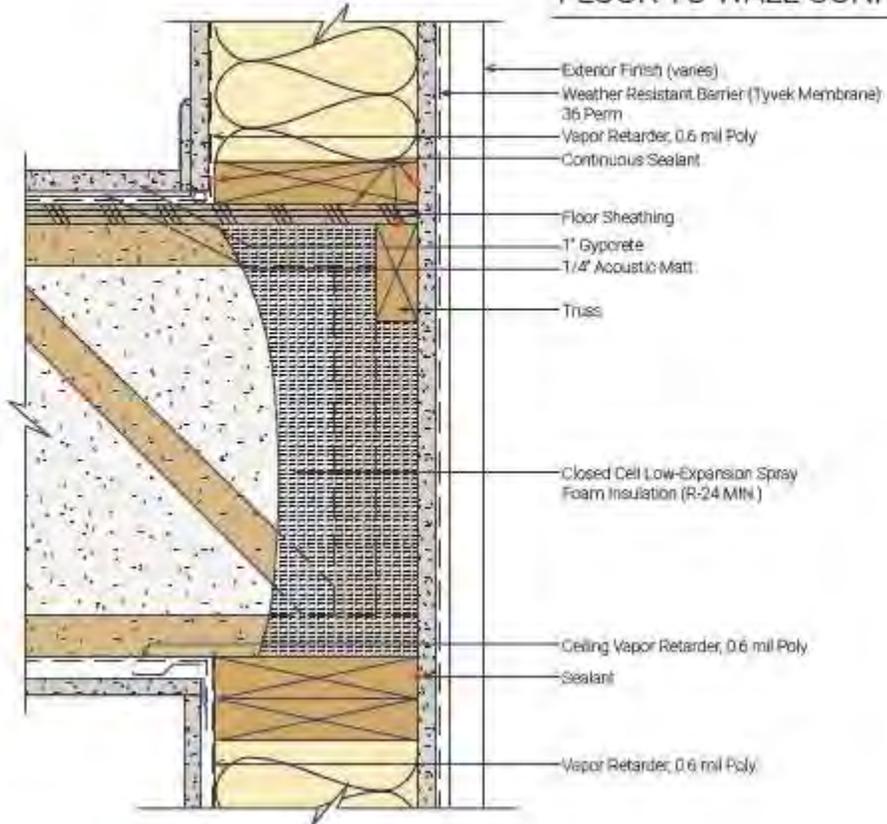
Standard



Passive House

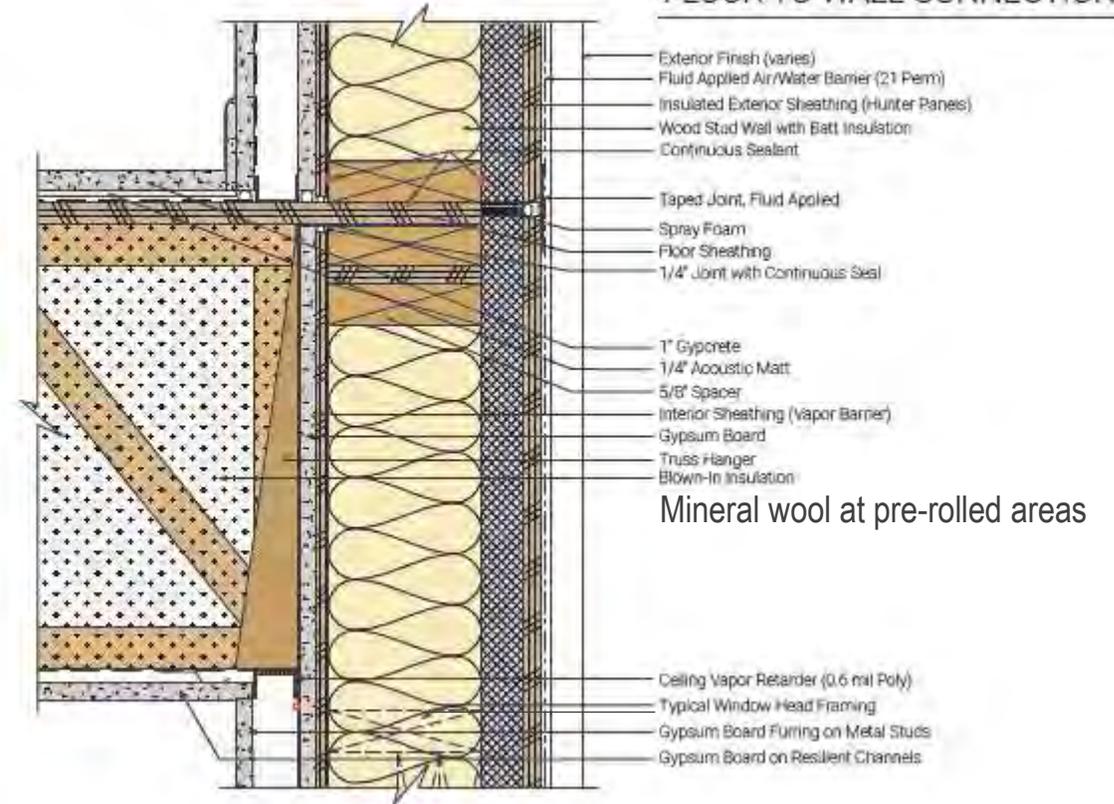
WALL ASSEMBLIES

STANDARD FLOOR TO WALL CONNECTION



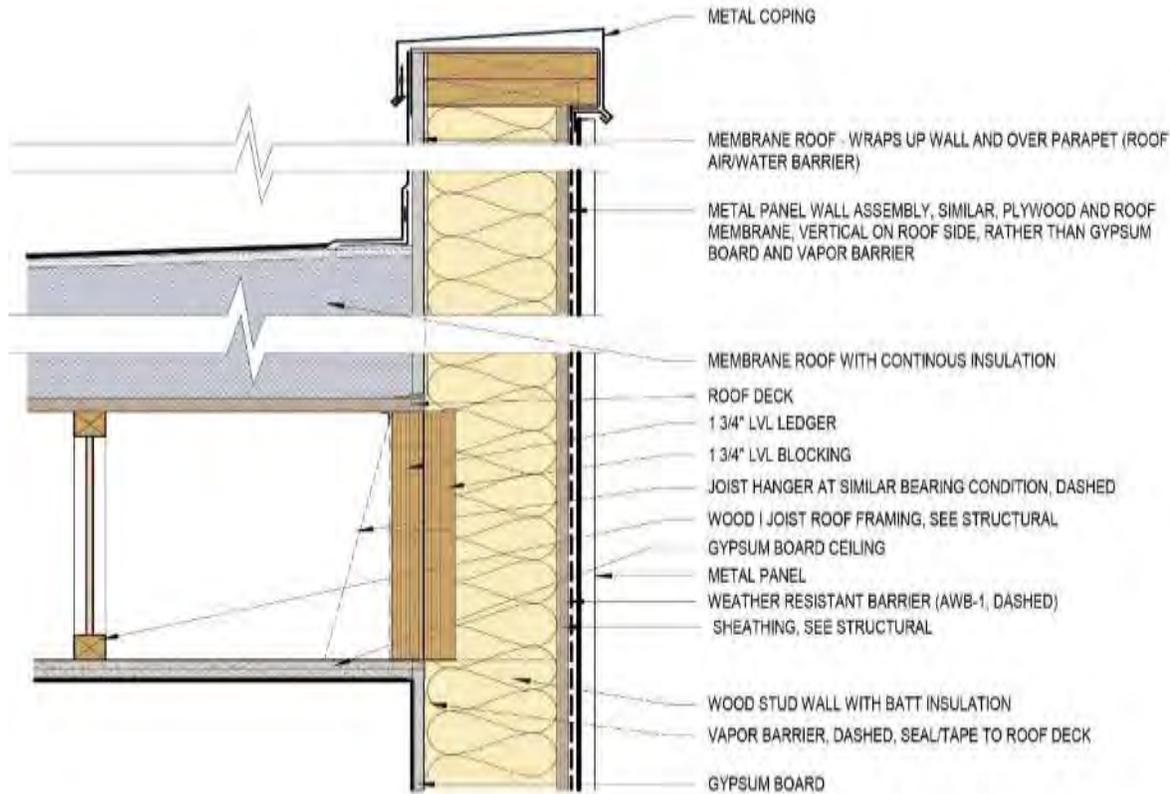
Standard

PASSIVE HOUSE FLOOR TO WALL CONNECTION

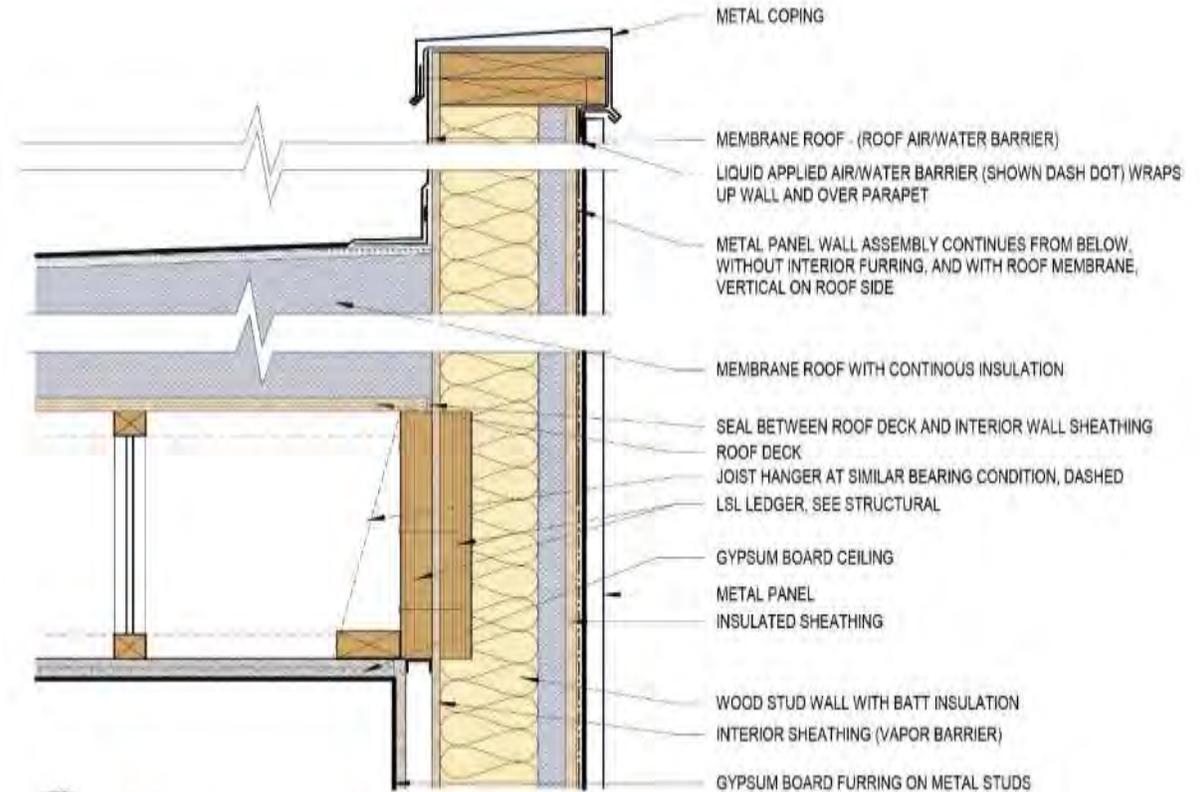


Passive House

FLOOR TO WALL CONNECTION

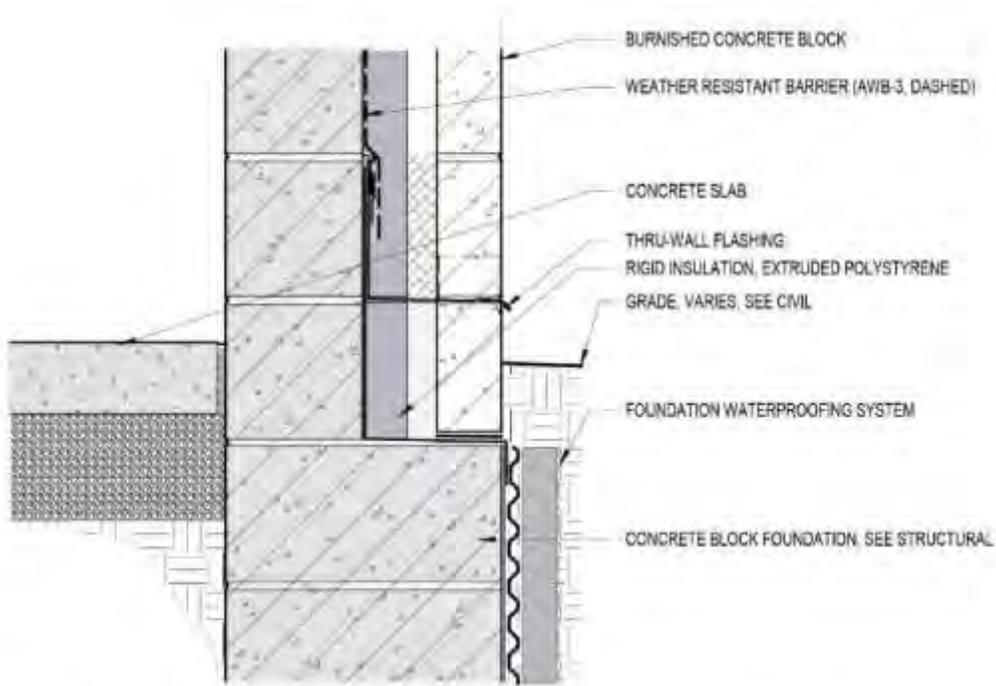


Standard



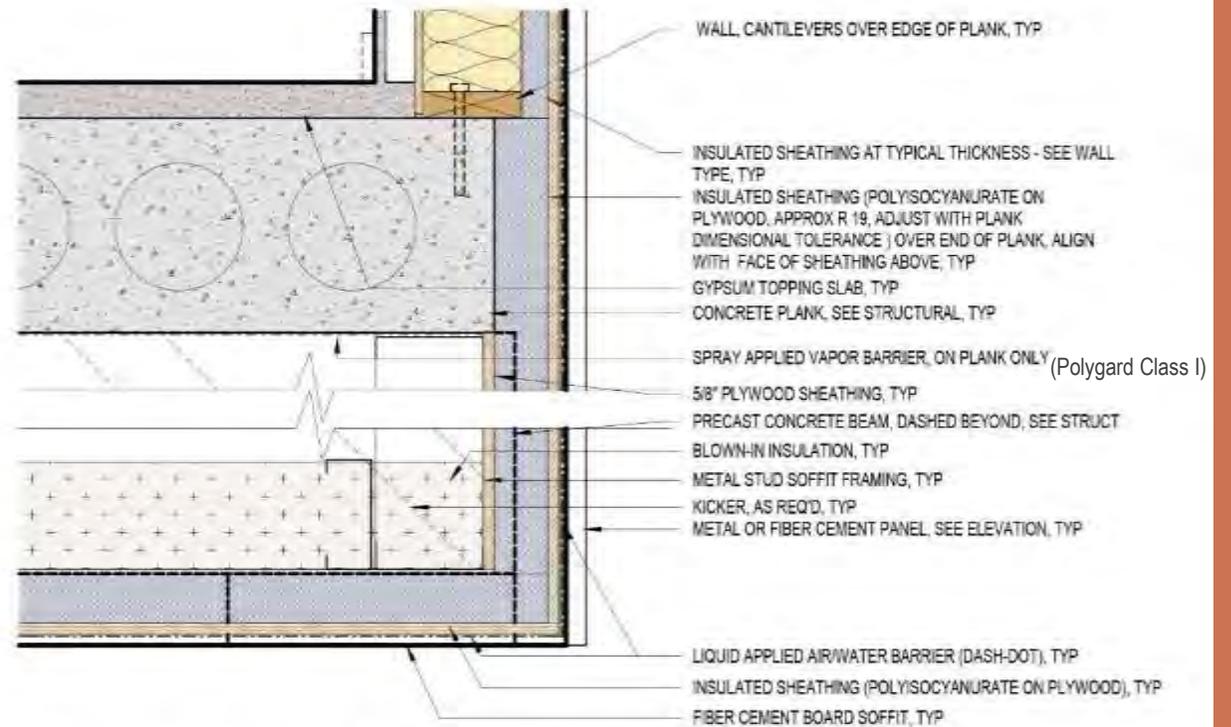
Passive House

WALL DETAILS : ROOF AT EXTERIOR WALL – NON BEARING



10 STANDARD - BASE OF WALL @ GARAGE SLAB
 1 1/2" = 1'-0"

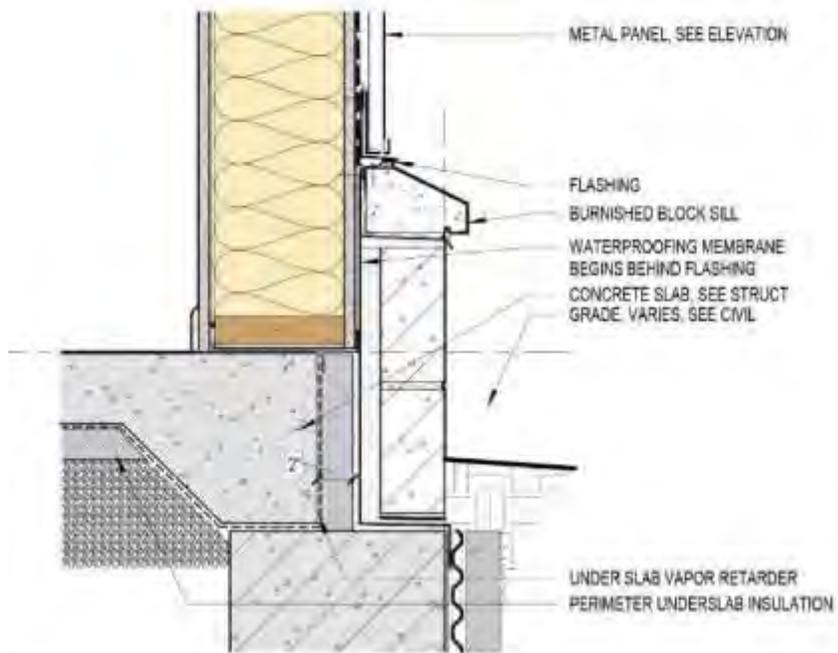
Standard



9 SECOND FLOOR ABOVE OPEN GARAGE- NON-BEARING
 1 1/2" = 1'-0"

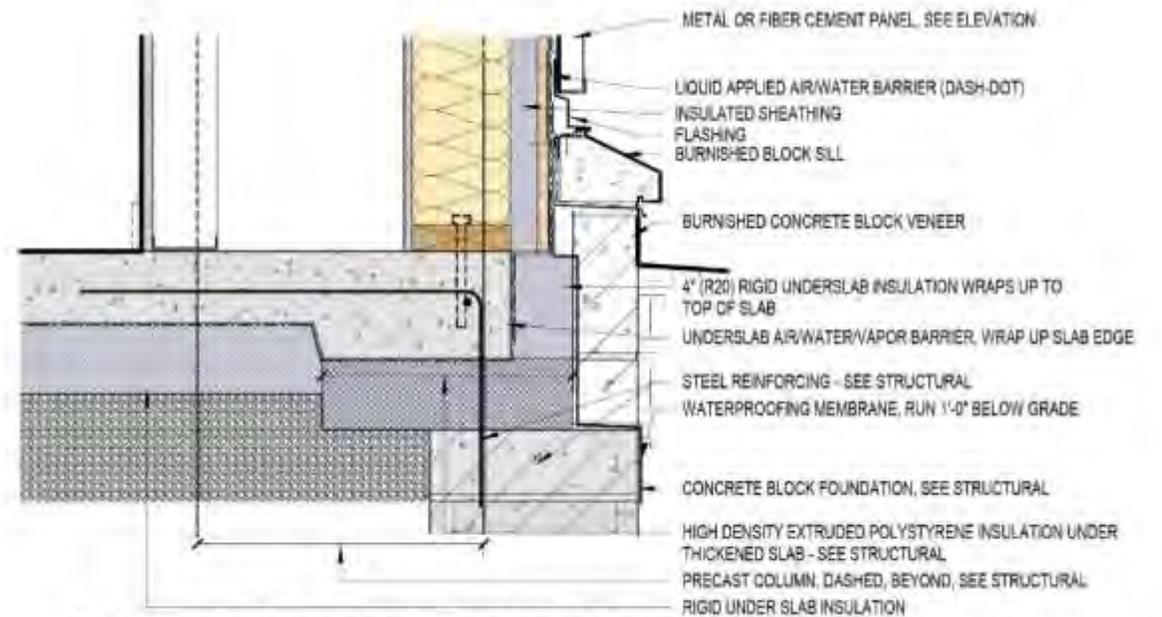
Passive House

WALL DETAILS AT GARAGE



11 STANDARD - BASE OF WALL @ VESTIBULE
 1/2" = 1'-0"

Standard



8 BASE OF WALL UNDER ENTRY CANOPY
 1/2" = 1'-0"

Passive House

WALL DETAILS : BASE OF WALL



Standard: Platform Framing



Passive House – Balloon Framing

FRAMING



PASSIVE HOUSE BALLOON FRAMING



Standard



Passive House

WINDOW OPENINGS



Standard - openings



Passive House – no openings

INSULATION CAVITY



Standard



Passive House

WINDOW OPENINGS



Standard



Passive House

GYPSUM BOARD



Standard – Platform



Passive - Balloon

FRAMING



WEATHER BARRIER



Standard – Sheet



Passive House – Fluid Applied

WEATHER BARRIER



PASSIVE HOUSE FLUID APPLIED VAPOR BARRIER

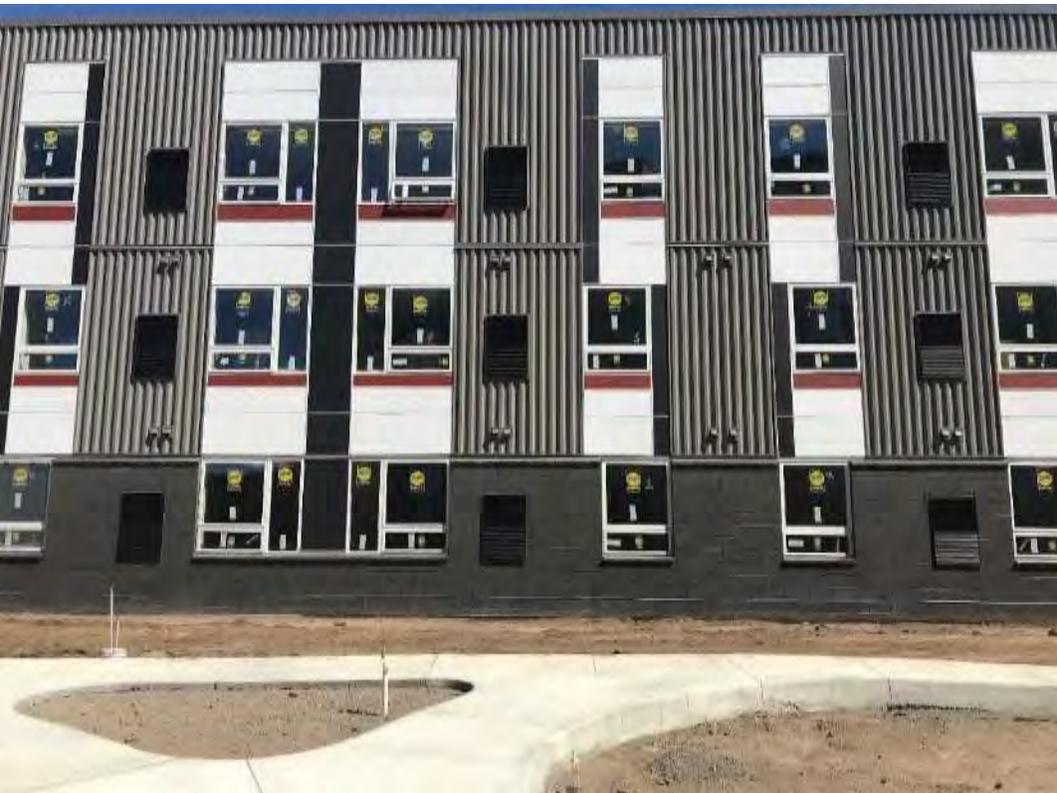


Standard – Rain Screen



Passive House – Rain Screen

CLADDING



Standard Building



Passive House

EXTERIOR WALL PENETRATIONS



PASSIVE HOUSE PARKING GARAGE CEILING

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 Achievers

BLOWER DOOR TEST RESULTS : PASSIVE HOUSE

	Building 1: 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	\$30,319
Simple Payback with Incentive	3.1	8.6
Energy Use Intensity (EUI) (modeled)	Baseline: 79.6 KBtu/ft ² /yr As Built: 51.6 KBtu/ft ² /yr	Baseline: 62.8 KBtu/ft ² /yr As Built: 37.7 KBtu/ft ² /yr
% Savings	35%	40%

53% from Standard baseline
27% better than Standard as built

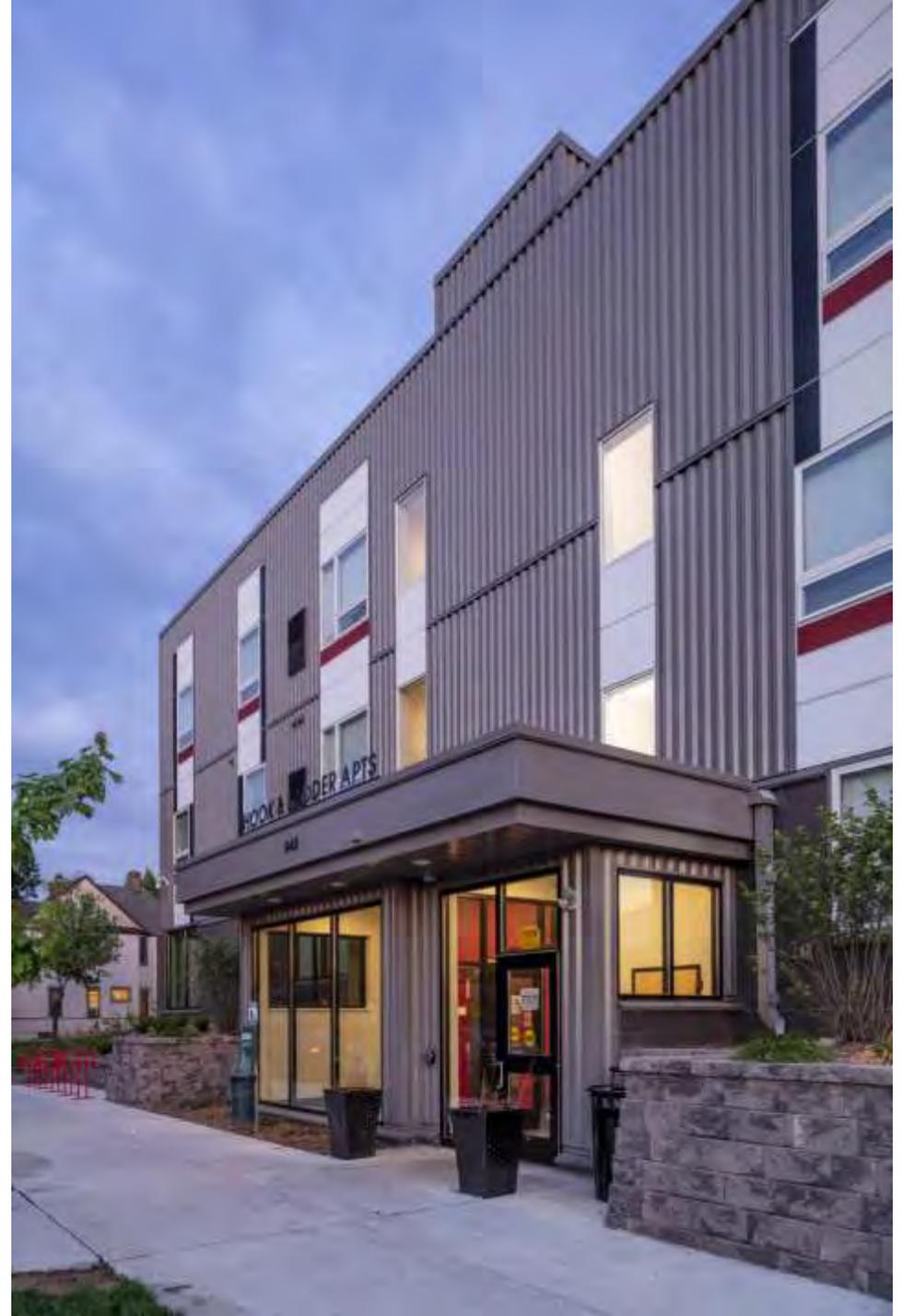
Source: Verification Reports prepared by Willdan

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 room less 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 : STANDARD BUILDING

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

EDA STRATEGY RESULTS : PASSIVE HOUSE





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> QUESTIONS?

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