PASSIVE HOUSE IN STUDENT HOUSING

WILLIAMS + WHEATON COLLEGE

PHIUS NAPHC 2018

SGA

ARCHITECTURE | PLANNING
INTERIOR DESIGN | VDC
BRANDED ENVIRONMENTS

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BRANDED ENVIRONMENTS

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SGA
WHO WE ARE

EXPERTS IN DESIGN FOR

- HIGHER EDUCATION FACILITIES
- CORPORATE OFFICE BUILDINGS
- CORPORATE INTERIORS
- CUTTING EDGE VIRTUAL DESIGN STUDIO

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THORNTON TOMASETTI

PROJECT CONTEXTS

IN 2017 SGA WAS HIRED TO:

WILLIAMS COLLEGE GARFIELD HOUSE

- Design 40 beds of student housing with aggressive energy performance EUI 28.
- Assist in decision to renovate existing 1850 residence hall or demolish and build new.
- Considered “deep energy retrofit”
- Design a project that feels like a “home” and not a residence hall.
- PHIUS was brought in by consulting team as a metric for consideration to advance college energy performance standards.
- Certify the project with USGBC as LEED GOLD
- Design a building contextual with surrounding residential neighborhood
- Integrate the building with the surrounding landscape.

PROJECT CONTEXTS

IN 2017 SGA WAS HIRED TO:

WHEATON COLLEGE RESIDENCE HALL

- Provide the maximum number of beds allowed by budget.
- Design a contextual solution fitting in the lower campus 1950's architecture.
- Decide fate of existing dorm at the site to renovate or demolish.
- Design a PHIUS certified building for maximum energy savings.
- No LEED certification pursued.
- Create a building that completes the quadrangle of first year student housing and offers a sense of community to this part of campus.
- Integrate a multi-purpose space for first year student orientation and gatherings.
- Design a brick clad building to fit in with surrounding buildings.

STATISTICS - 2 CASE STUDIES IN PASSIVE HOUSE FOR STUDENTS

WILLIAMS COLLEGE GARFIELD HOUSE

- Wood framed construction with HardiPlank siding
- Traditional contextual design
- 2.5 story 40 bed residence hall
- Scheduled occupancy fall 2019
- Suite style living arrangement (6 students/group/bath)
- No active cooling

Building area	Construction cost	Cost/SF	Total beds	Area /Student	Cost/ Bed	Design EUI
16,500 gsf	$9.5M	$575.00	40	413 SF/bed	$237,500	28.2

WHEATON COLLEGE RESIDENCE HALL

- Steel frame/ precast plank construction & brick veneer
- Modern contextual design (1950's campus)
- 3.5 story 178 bed residence hall
- Scheduled occupancy fall 2019
- Wing style living arrangement (30 students/Wing/bath)
- Cooling provided

Building area	Construction cost	Cost/SF	Total beds	Area /Student	Cost/ Bed	Design EUI
45,000 gsf	$21.5M	$466.00	178	253 SF/bed	$120,800	26.6

PROJECT SITES

- Suburban site
- Orientation predetermined
- Expressed connections to nature

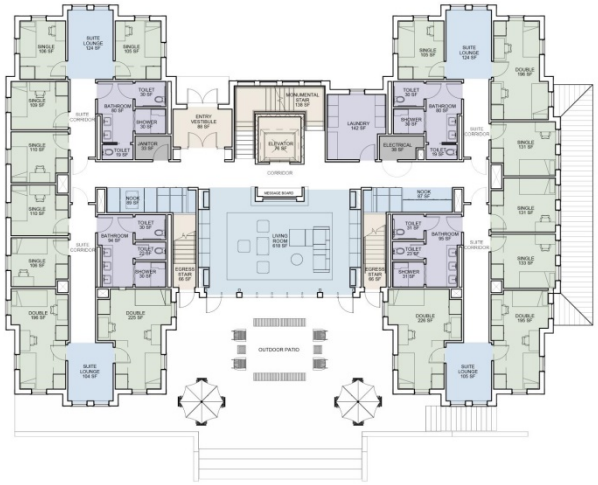
WILLIAMS

NORTH

WHEATON

PLAN LAYOUTS

WILLIAMS COLLEGE
GARFIELD HOUSE
Suite style arrangement 6 students/bath

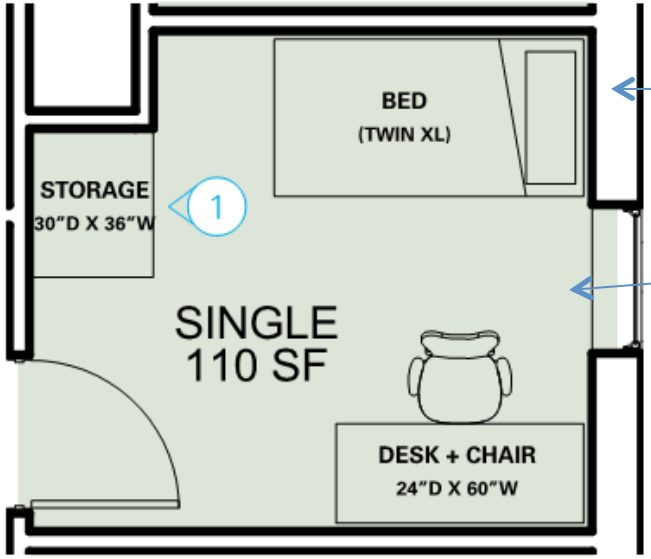


WHEATON COLLEGE
RESIDENCE HALL
Double loaded corridors with central lounge/toilet core

WHEATON

EXPRESSED CONNECTION TO NATURE

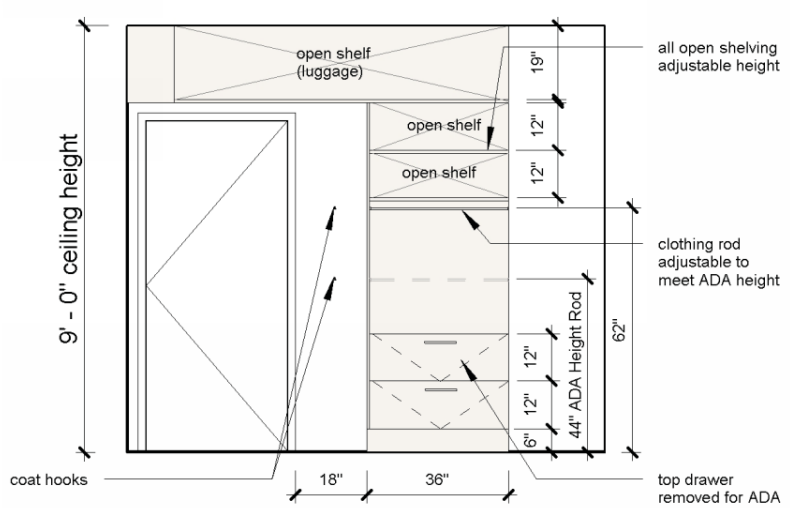
PASSIVE HOUSE DESIGN COMPONENTS - ROOMS



Phase change materials in the walls and ceilings mitigate heat on hot days

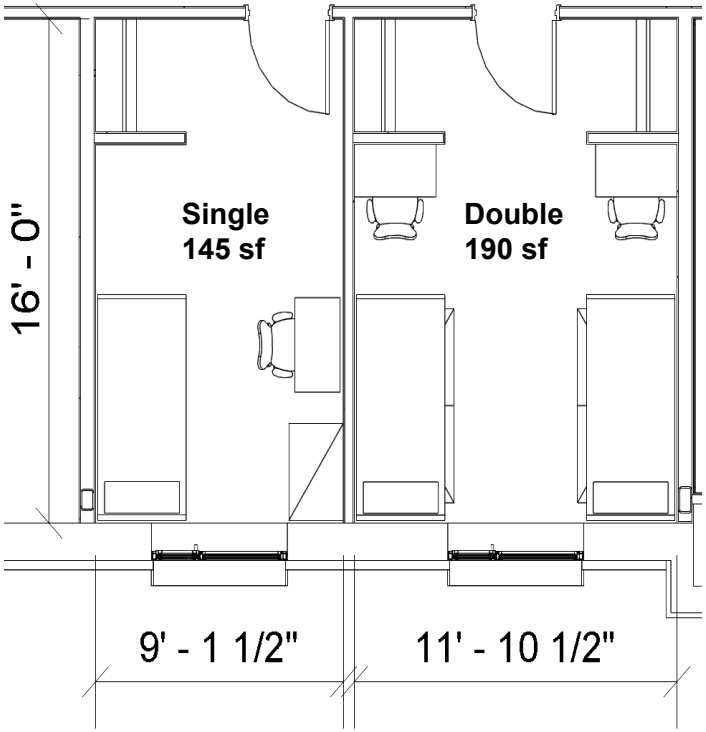
Electric radiant heat source can be located off the floor to free floor space – only one per room required

Operable windows provide fresh air for student comfort

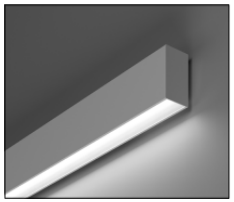


WILLIAMS COLLEGE

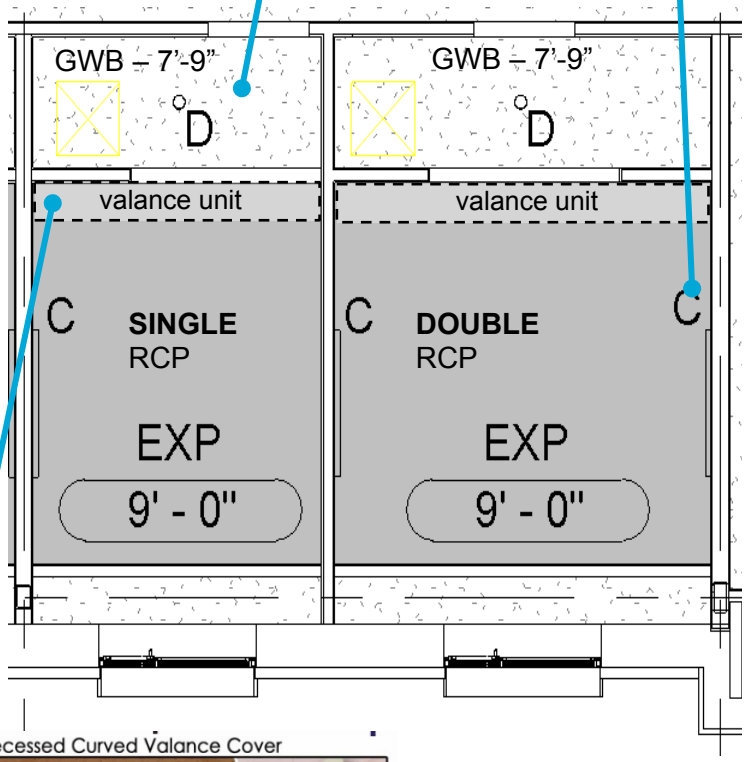
PASSIVE HOUSE DESIGN COMPONENTS - ROOMS



D - Surface mounted downlight



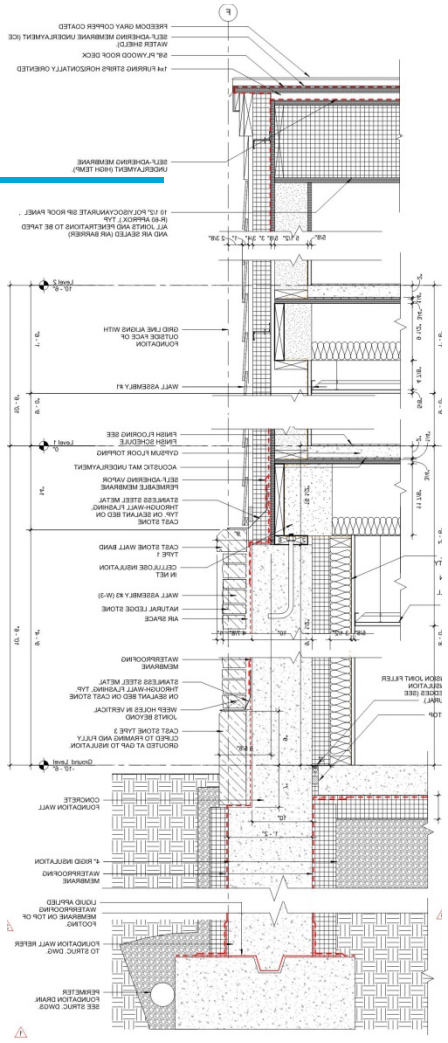
C – Wall mount up / down light



EXP : exposed underside of slab ceiling, painted white

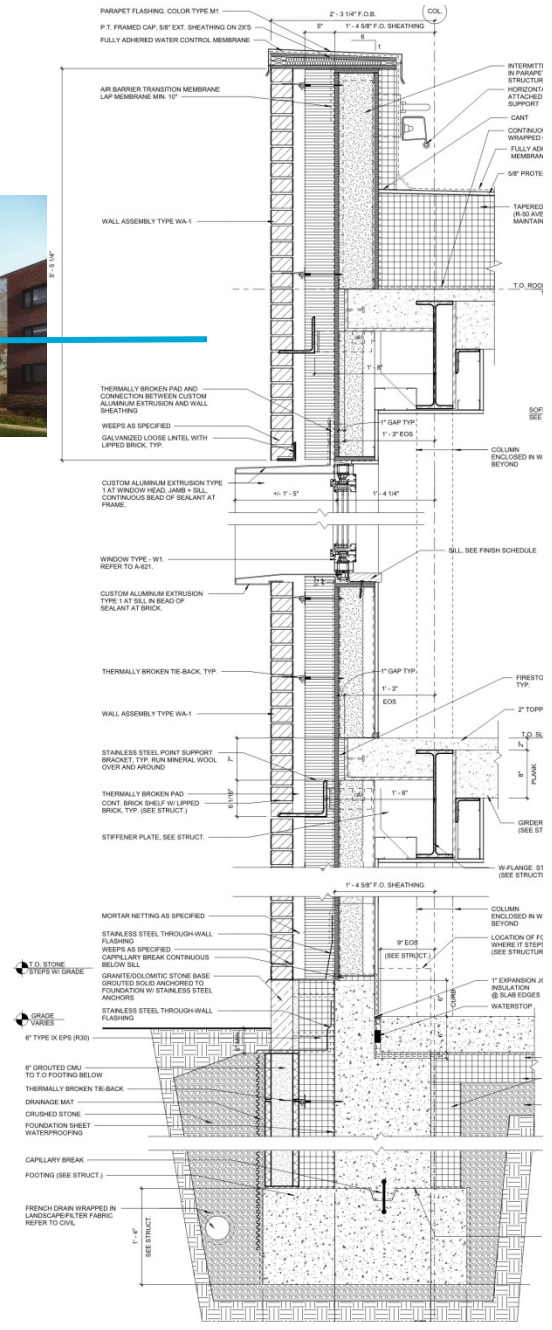
WHEATON COLLEGE

ENVELOPE



ROOF: R-60
WALLS: R-38
SLAB: R-20
THERMAL MASS
PHASE CHANGING MATERIAL

WILLIAMS



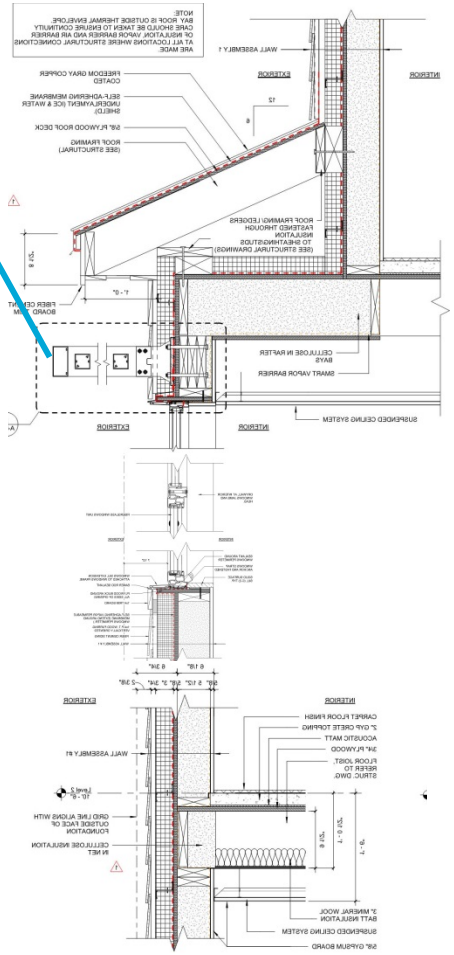
ROOF: R-50
WALLS: R-32
SLAB: R-20
FLEX SPACE OUTSIDE PH

WHEATON

GLAZING AND SHADING

WINDOWS:
U 0.17
SHGC 0.369 -0.558

WINDOW/WALL: 30%

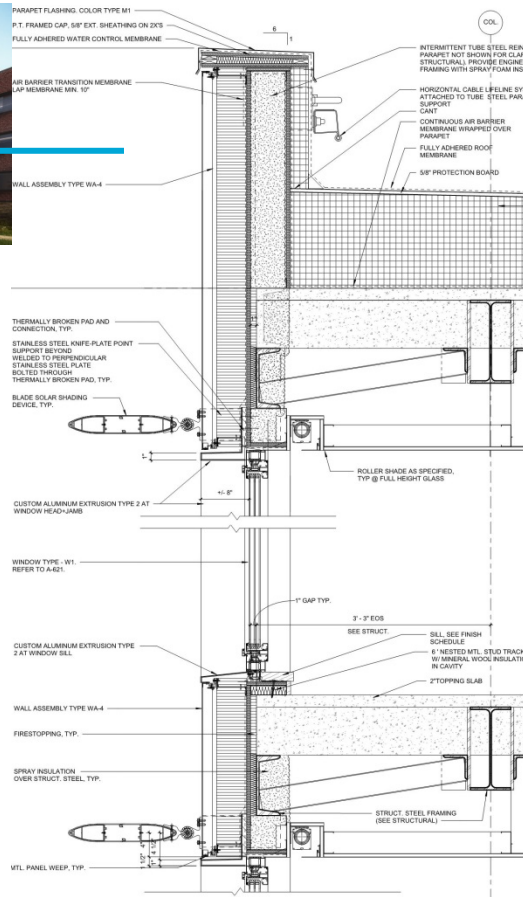


WILLIAMS

WINDOWS:
U 0.2
SHGC 0.37

CURTAINWALL:
U 0.18
SHGC 0.25

WINDOW /WALL: 31%

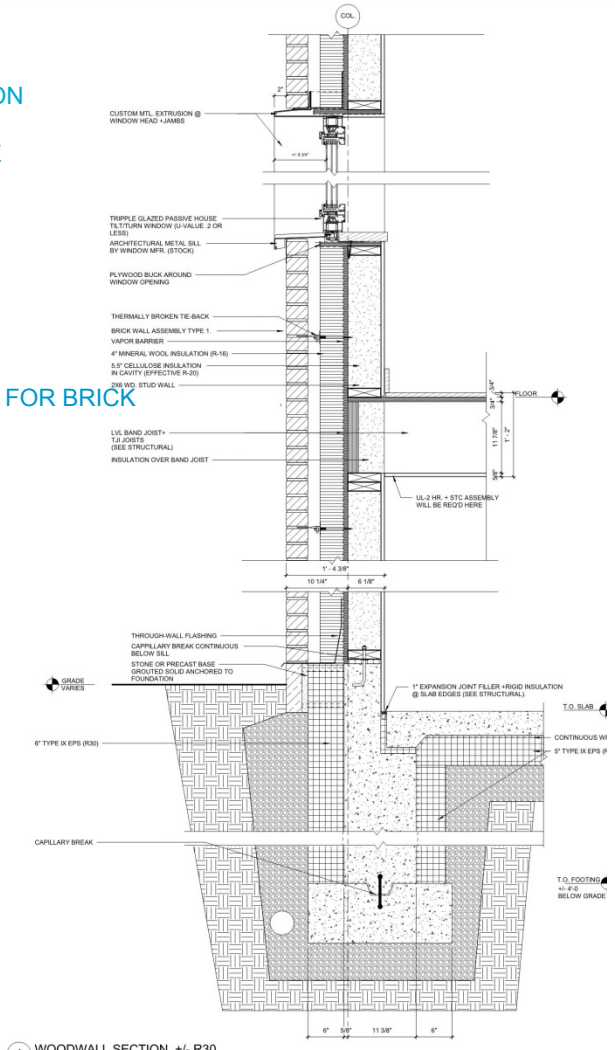


WHEATON

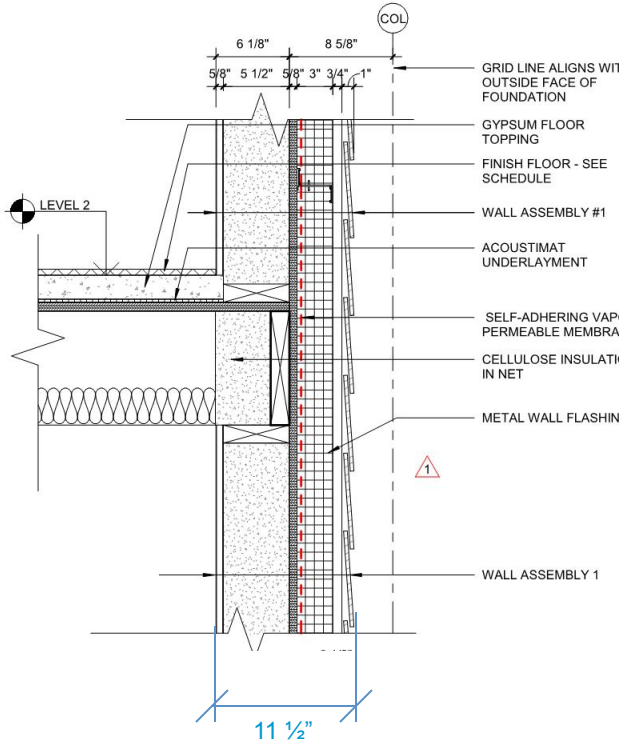
WOOD VS. STEEL - WHEATON COLLEGE

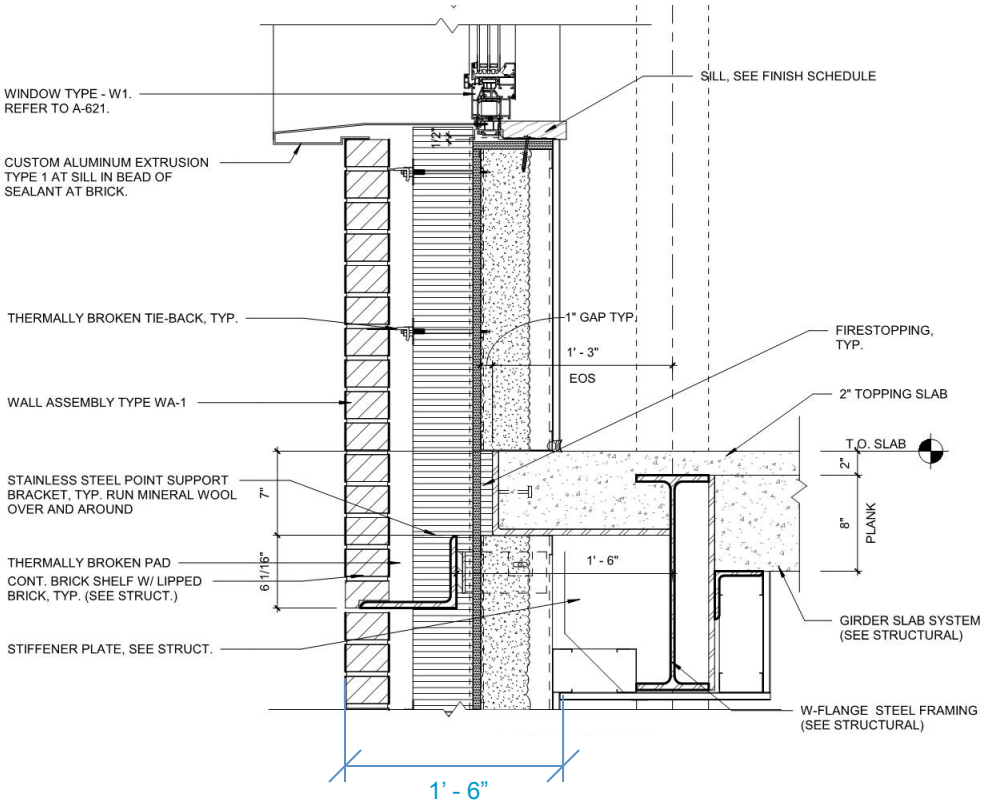
WOOD:
- MORE COMPACT STRUCTURE
- POTENTIALLY FASTER CONSTRUCTION
- LESS LEAD TIME THAN STEEL
- HIGHER CAVITY EFFECTIVE R-VALUE
- LESS POTENTIAL FOR STRUCTURAL
- THERMAL BRIDGES
- RENEWABLE RESOURCE

STEEL+COMPOSITE DECK:
- LONGER SPANS
- BUILT IN FIRE RATING AT FLOORS
- LESS RELIEVING ANGLES REQUIRED FOR BRICK
- RECYCLED CONTENT
- GREATER PERCEIVED DURABILITY



WOOD VS. STEEL – WILLIAMS VS. WHEATON





WILLIAMS:

- NO ADDITIONAL STRUCTURE BEYOND WOOD STUDS
- MORE FLEXIBLE STRUCTURE/OPENINGS CAN BE FIELD MODIFIED
- THERMALLY BROKEN Z-GIRTS ONLY PENETRATION IN RAINSCREEN

WHEATON:

- NEED TO COORDINATE STEEL COLUMNS IN PLAN WITH PARTITIONS
- COMPLICATED SLAB EDGE DETAIL WITH UPSET STEEL FOR HEADROOM
- STEEL/PLANK NEED TO BE CLOSELY COORDINATED, INCLUDING WITH HVAC FOR ALL PENETRATIONS
- THERMALLY BROKEN BRICK TIES, RELIEVING ANGLES AND Z-GIRTS

Williams College Garfield Residence

Passive House Design Features

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Williams College Garfield Residence

High Performance Ventilation

ERV Efficiency 84%

- Swegon Unit
- Must be AHRI/ PHI Certified

Intermittent Bathroom Vent

- Saves 400 CFM of Exhaust = 4% site EUI savings

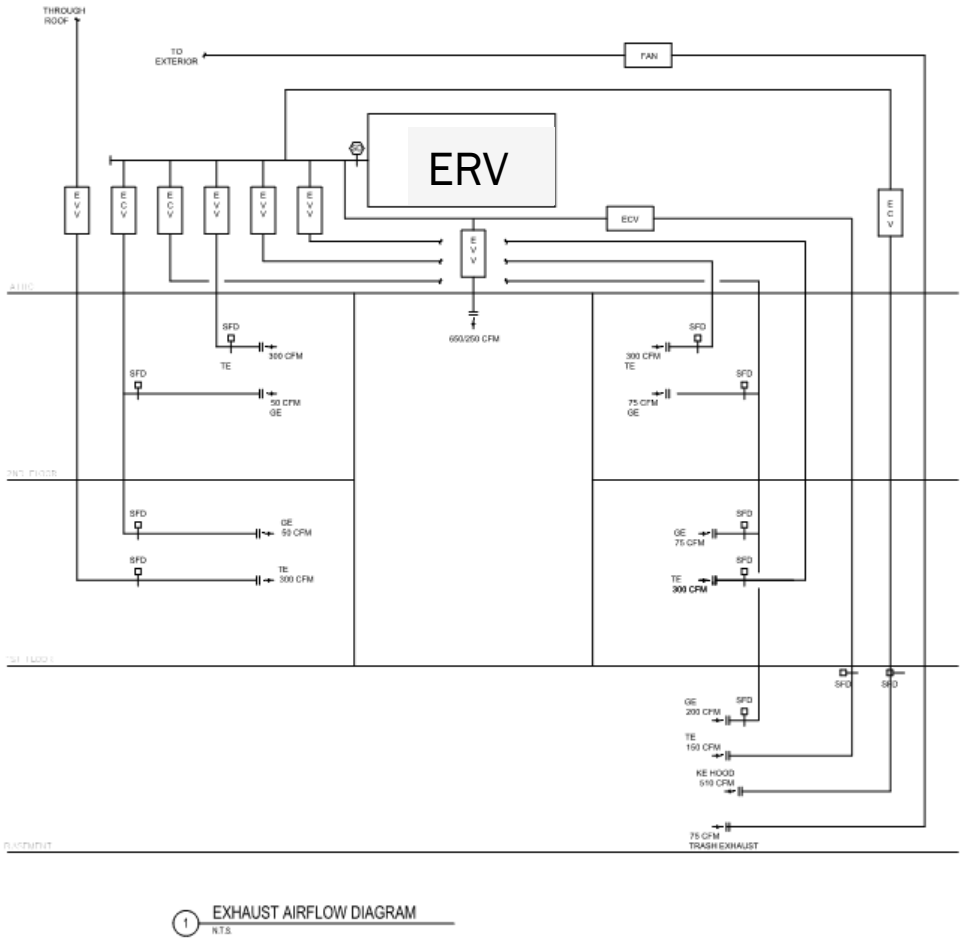
Balanced Ventilation Design

- Limit Exhaust only systems (Trash room)

Laundry Rooms

- Through wall make up air

Use Demand Control Ventilation in Living Room



1 EXHAUST AIRFLOW DIAGRAM
N.T.S.

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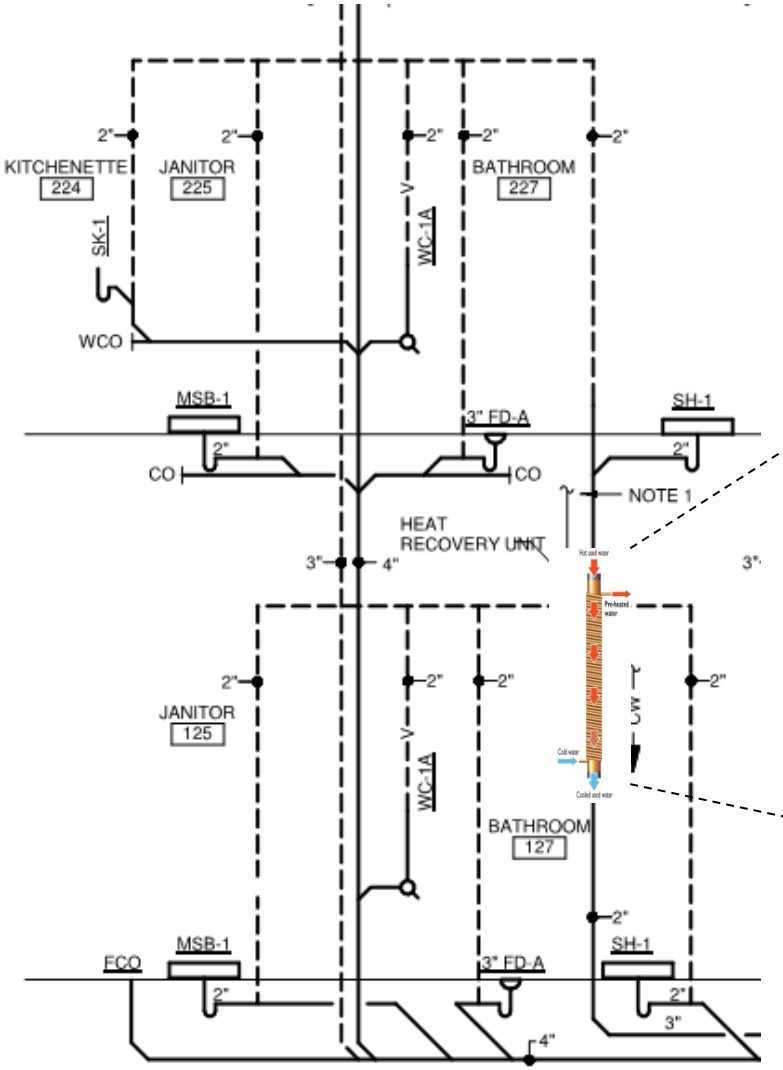
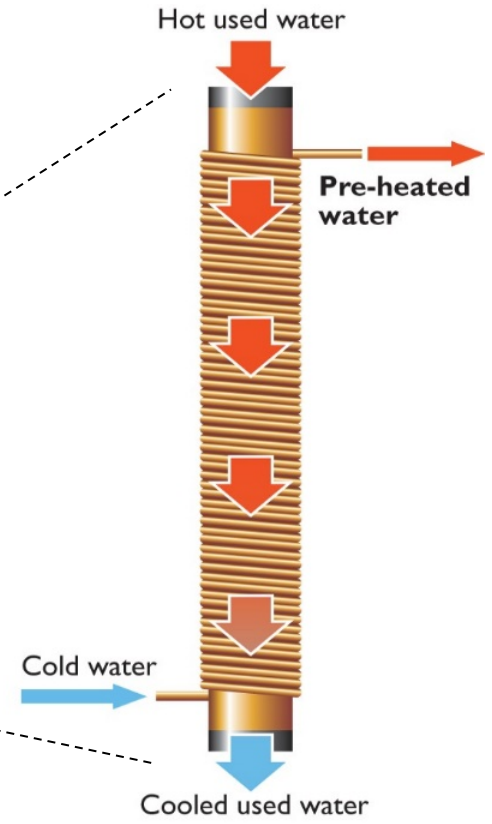
Drainwater Heat Recovery





Reduces DHW Heating Energy by ~20-30%

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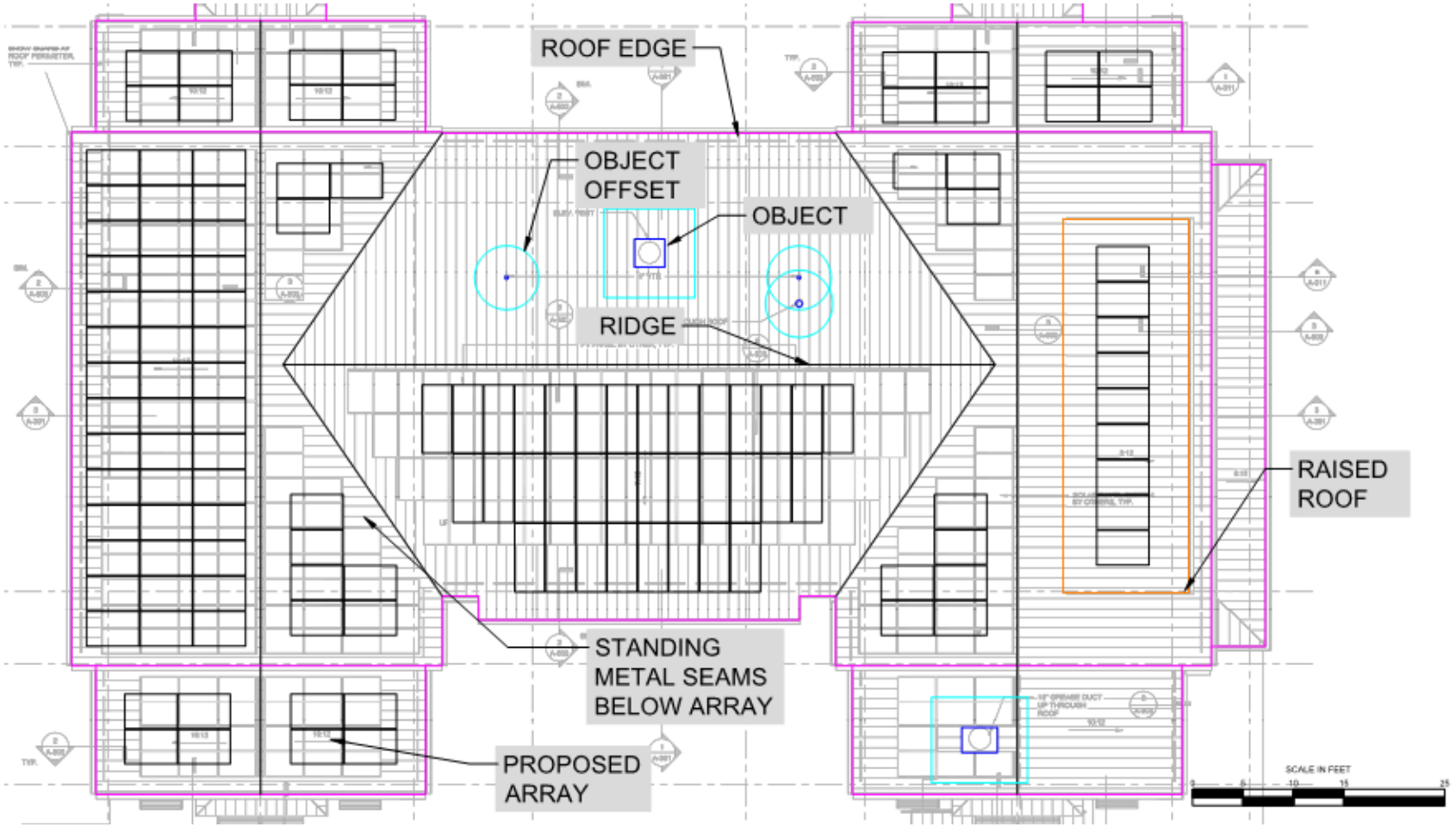
55 kW PV Array

48,000 kwh/year



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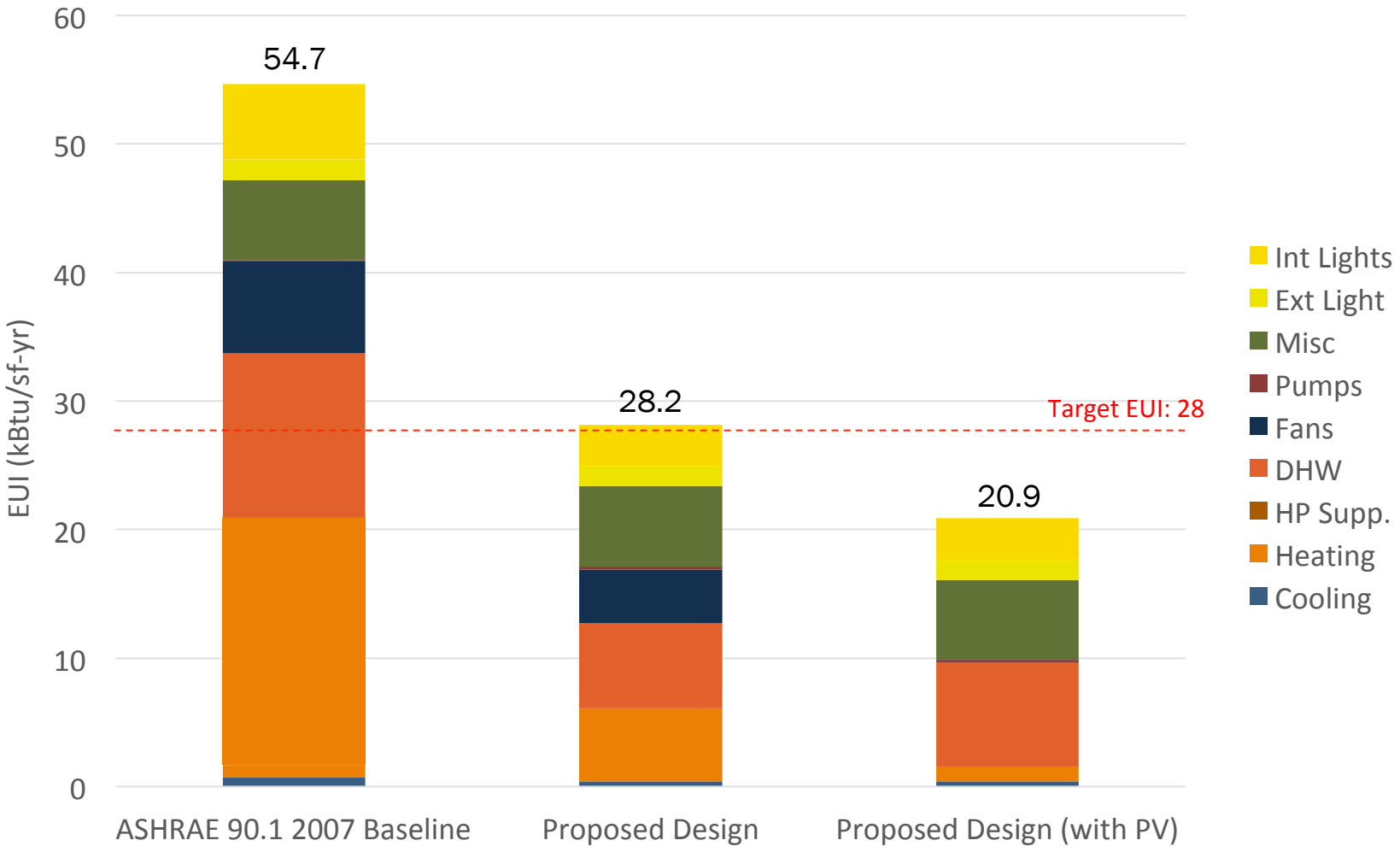
Energy Analysis - Energy Use Intensity Breakdown by Design Case



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Passive House
Analysis

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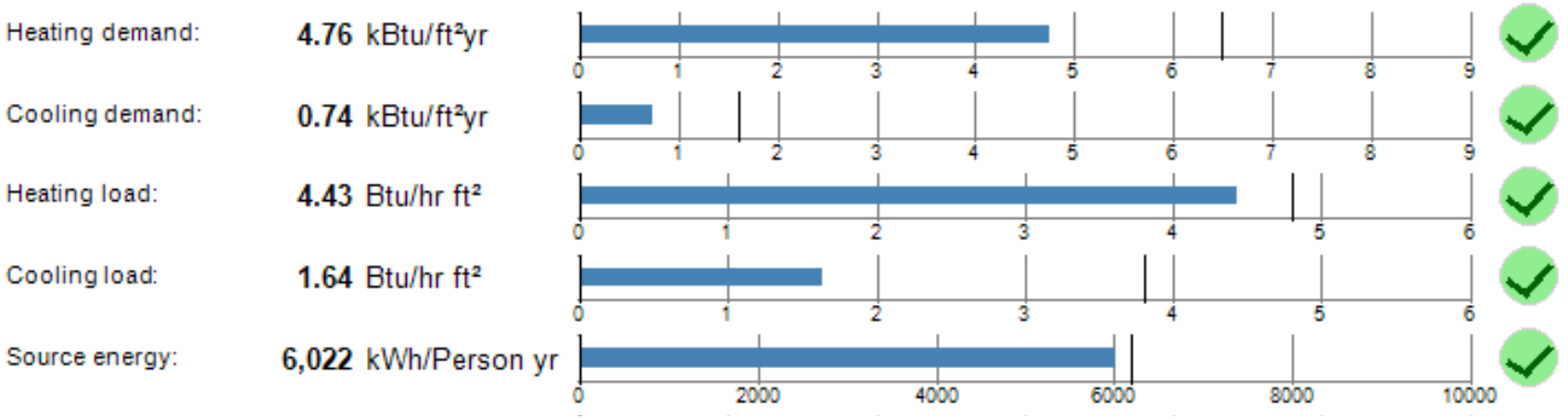
Passive House Model Results



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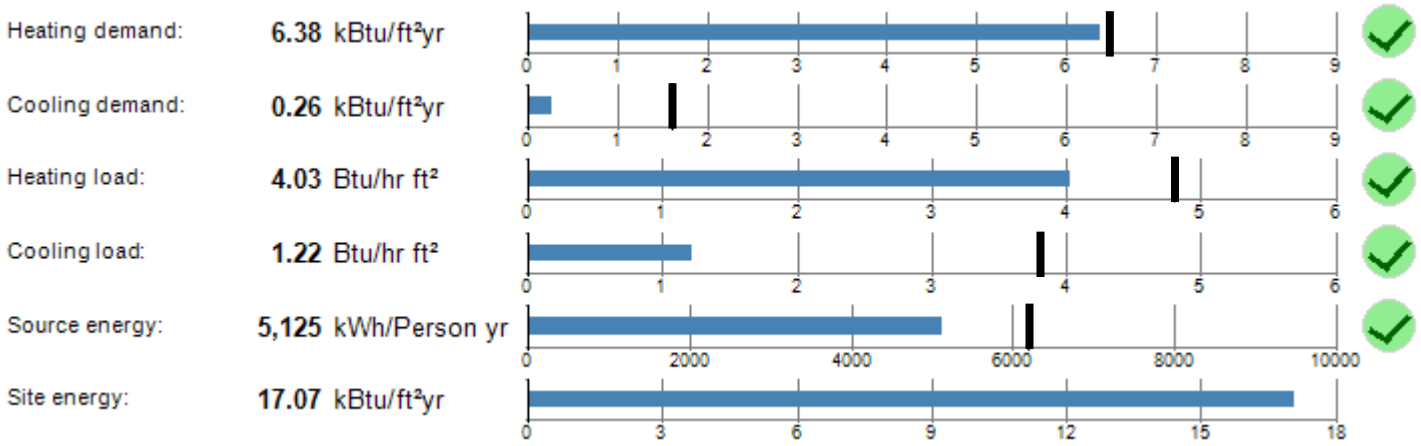
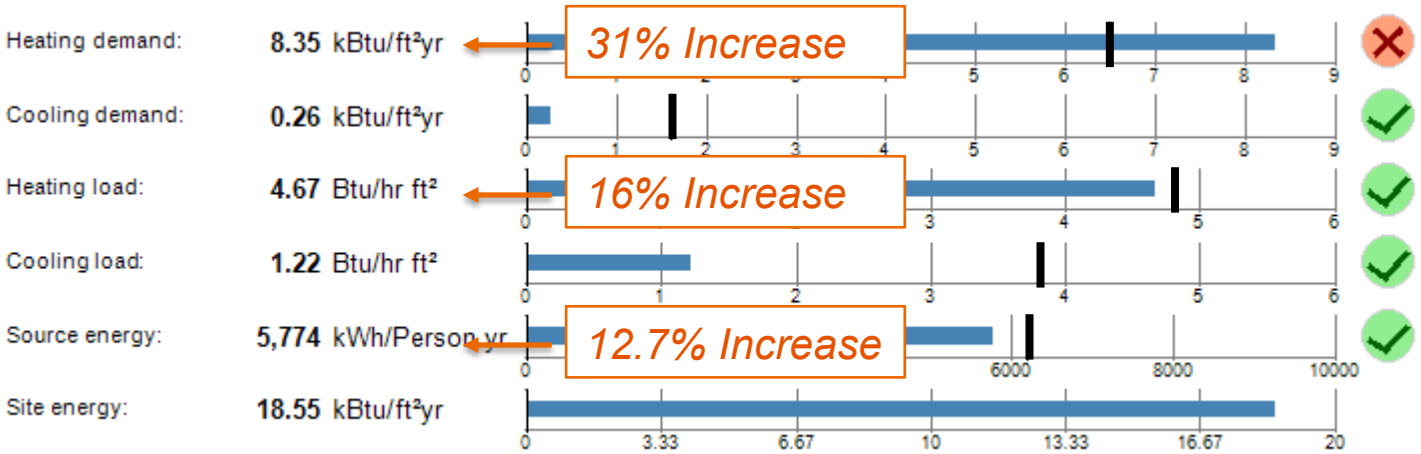
Energy Recovery Ventilation Unit Efficiency

Current Assumption : 84%



Alternative Assumption : 75%



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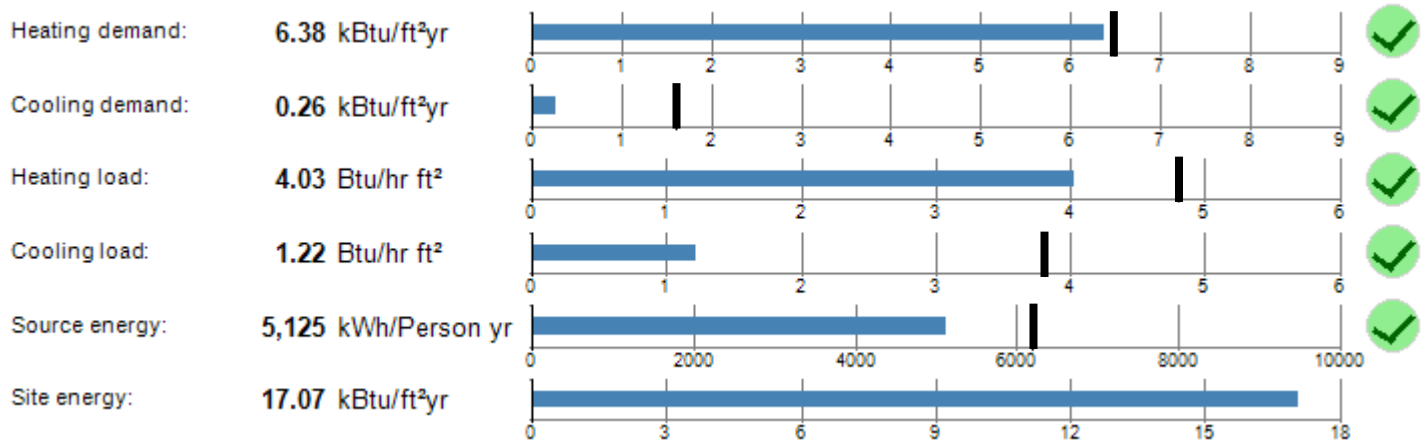
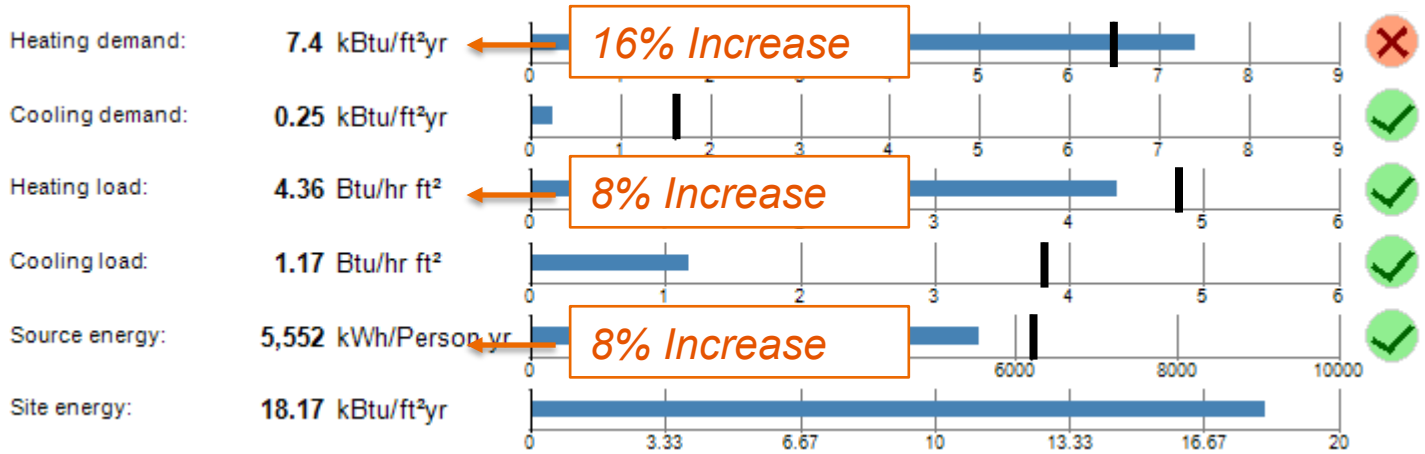
Ventilation Analysis

Current Assumption : Continuous 2300 cfm + Kitchen 400cfm



Alternative Assumption : Continuous 3000 cfm + Kitchen 400cfm



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Williams College Garfield Residence

Phase Change Material Study

PCM Mats

- 16" wide x 48" long
- 24" wide x 48" long

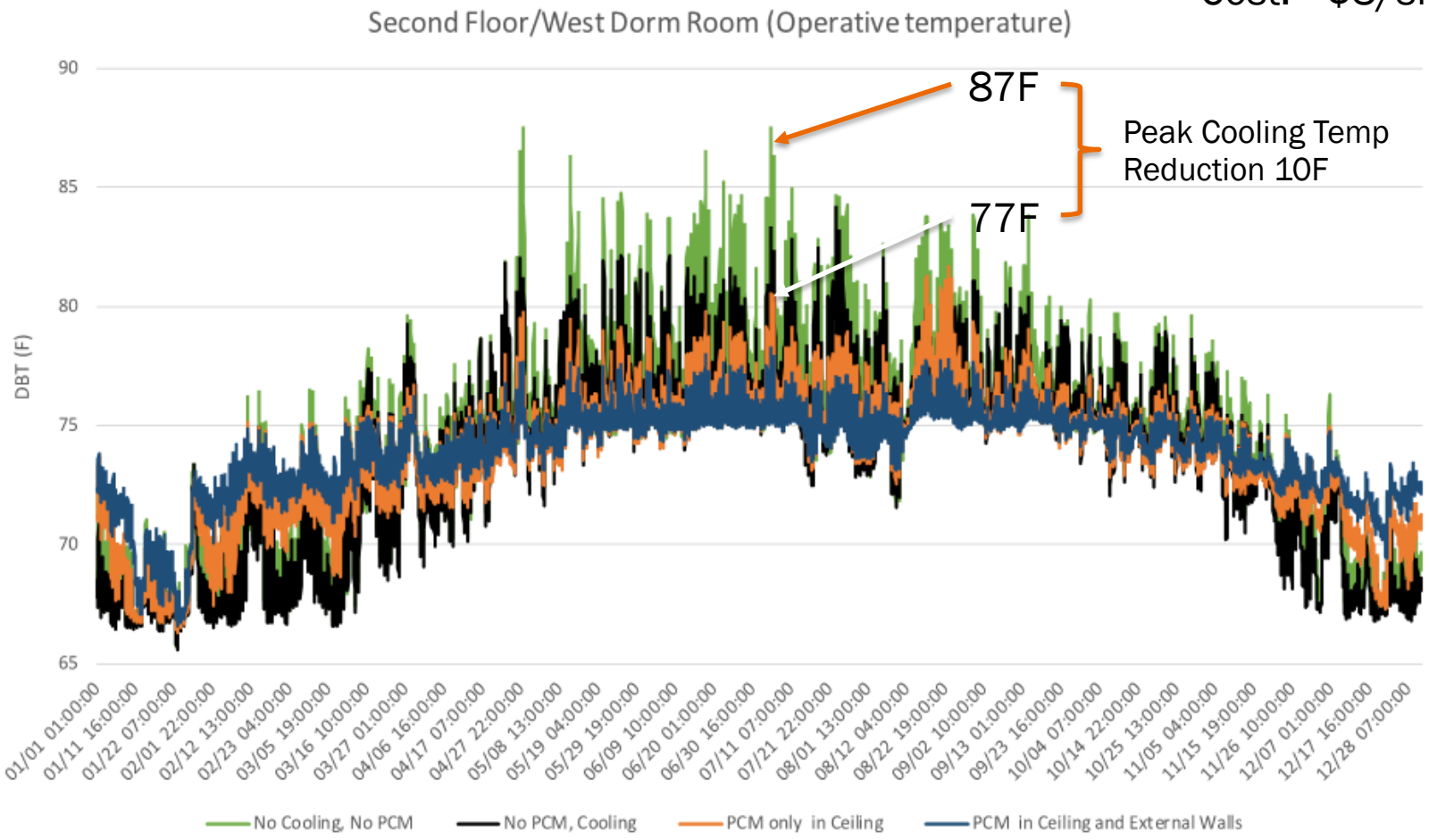
- Class A Fire Rated
- Salt Hydrate
- 25 Year Longevity Warranty

- Standard Melt/Freeze Temps

55°F | 65°F | 71°F | 73°F | 78°F | 84°F

Cost: ~$3/sf

THERMAL SIMULATION MODEL RESULTS



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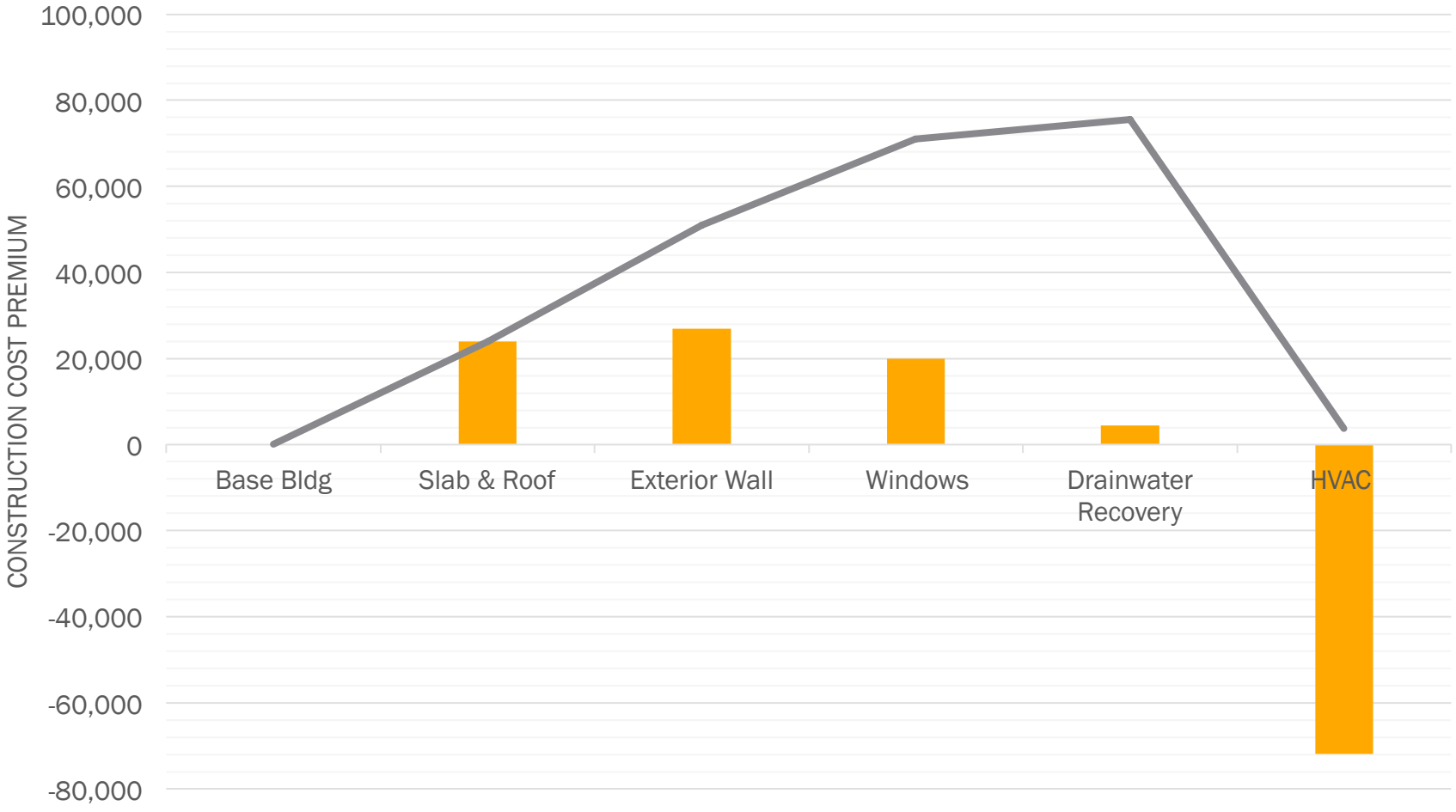
Passive House Cost Analysis



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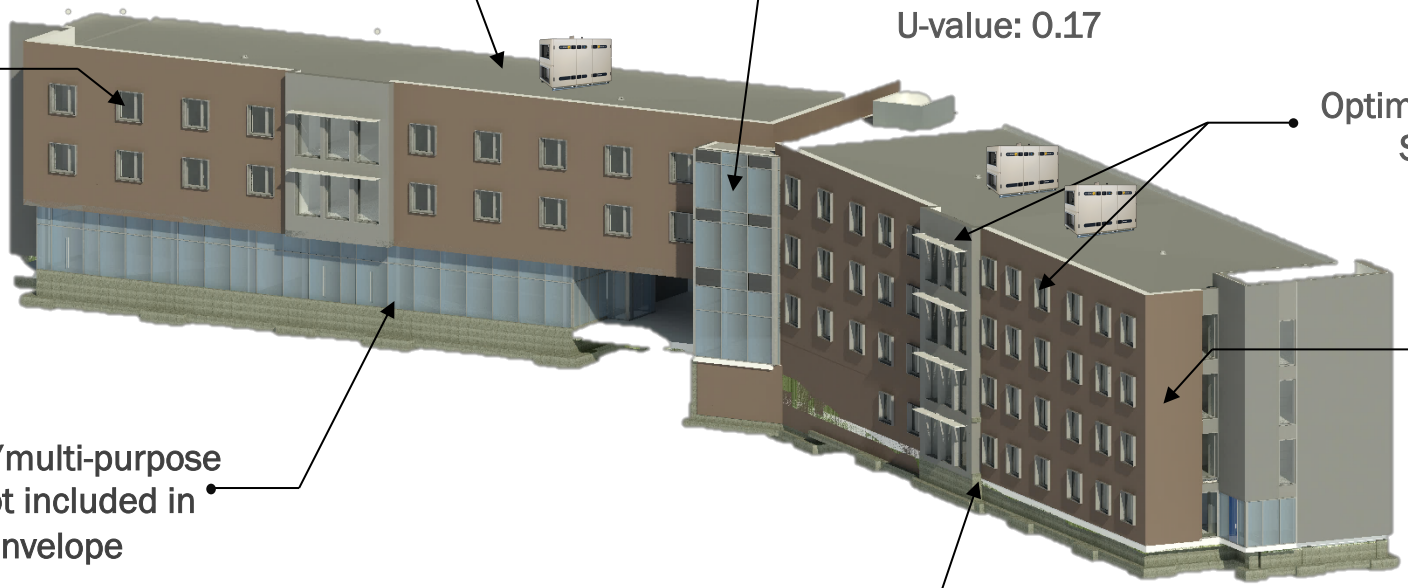
Wheaton College – Dormitory

High Performance Envelope Systems



High Performance Triple Glazed Windows
U-value: 0.18

Roof
R-value: 50

High Performance Triple Glazed Curtainwall
U-value: 0.17

Optimized Exterior Shading

Walls
R-value: 32

Commons/multi-purpose center not included in PH envelope

Airtight Construction
Infiltration rate: 0.05 CFM/SF

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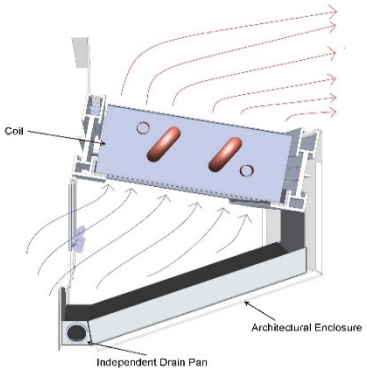
Wheaton College – Dormitory

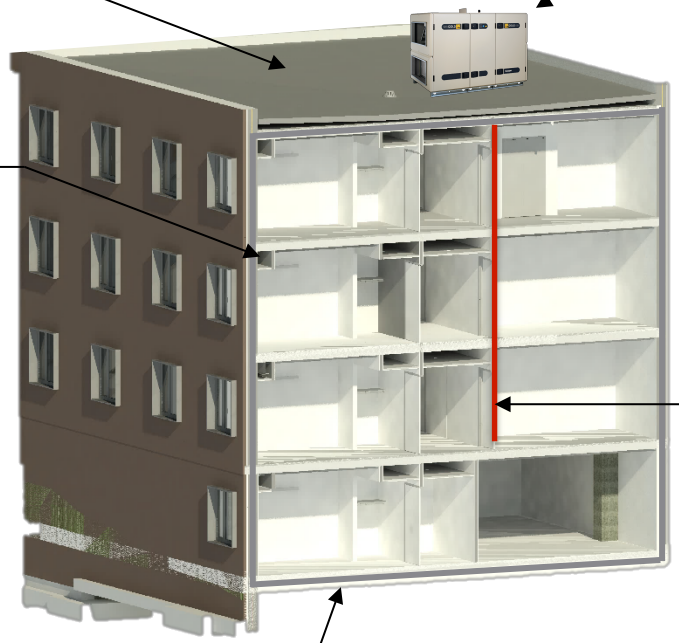
High Performance HVAC Systems

Rooftop PV Capacity
Estimate ~80kw

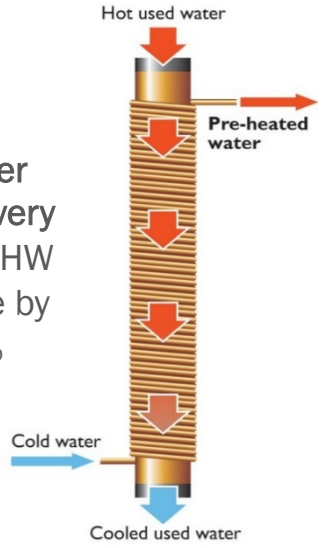
High Efficiency Energy
Recovery Ventilation
84% Efficiency

4 pipe Valance Units
Condensing Boilers: Hot water
Dry Cooler/WSHP: Cooling





Drainwater
Heat Recovery
Reduces DHW
energy use by
20-30%



Continuous Air Barrier
& Continuous Insulation
Enclosed thermal envelope

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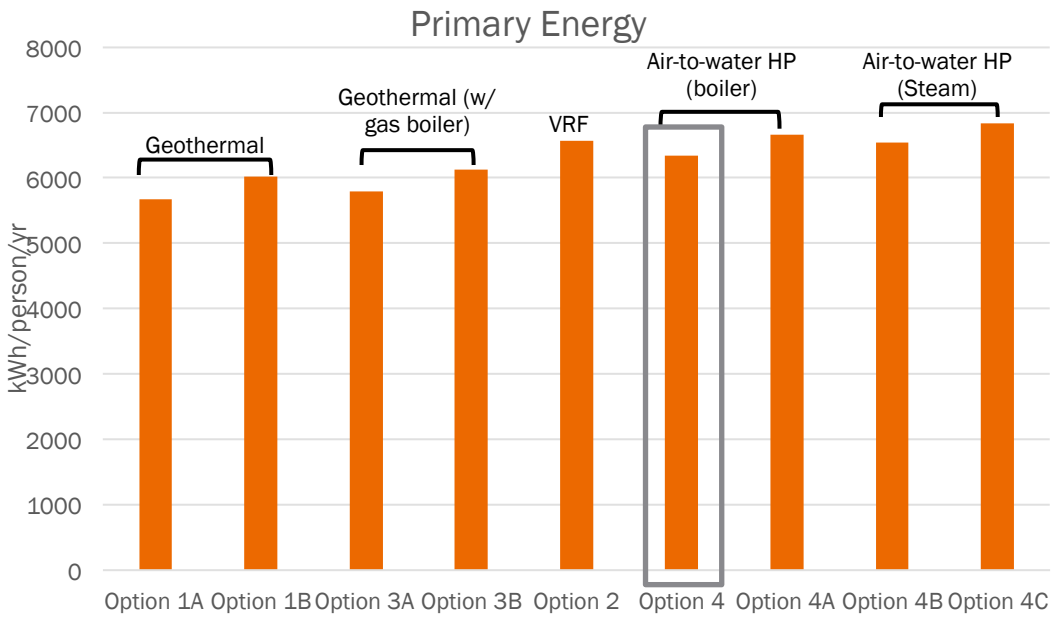
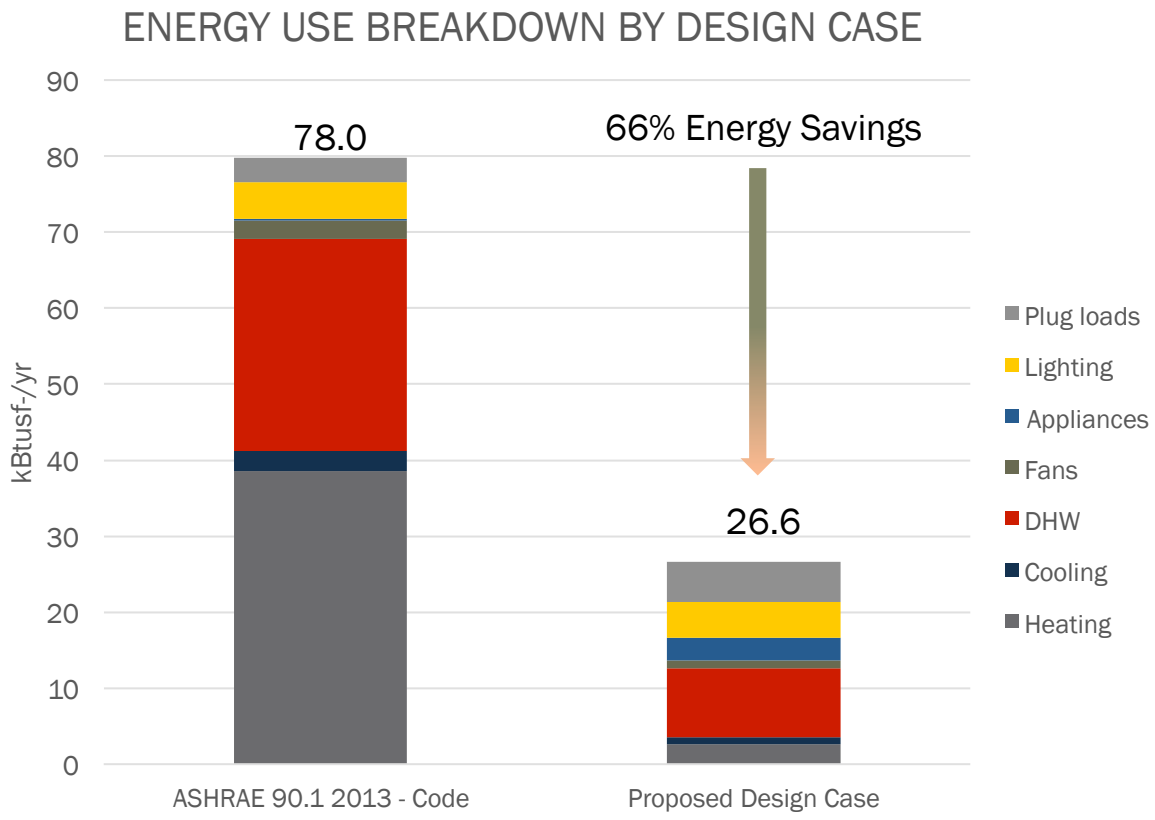
HVAC System Selection



	Central Plant	Distribution
Option 1A	Geothermal	Valance Unit
Option 1B	Geothermal	FCU
Option 2A	VRF	VRF
Option 3A	Geothermal (back up boiler)	Valance Unit
Option 3B	Geothermal (back up boiler)	FCU
Option 4	Air-to-Water Heat Pump (Boiler)	Valance Unit
Option 4A	Air-to-Water Heat Pump (Boiler)	FCU
Option 4B	Air-to-Water Heat Pump (Steam)	Valance Unit
Option 4C	Air-to-Water Heat Pump (Steam)	FCU

Wheaton College – Dormitory

Energy Use Intensity Breakdown by Design Case



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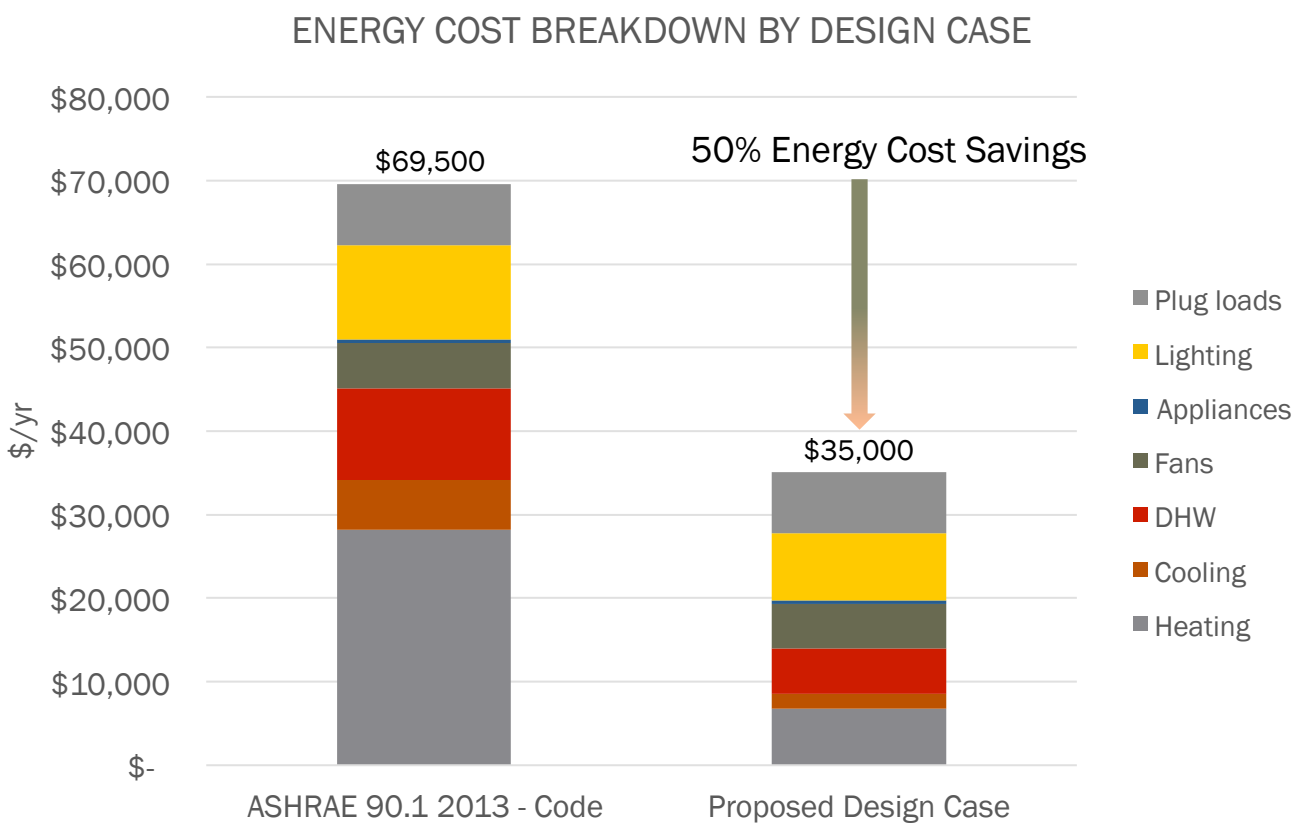
Energy Analysis



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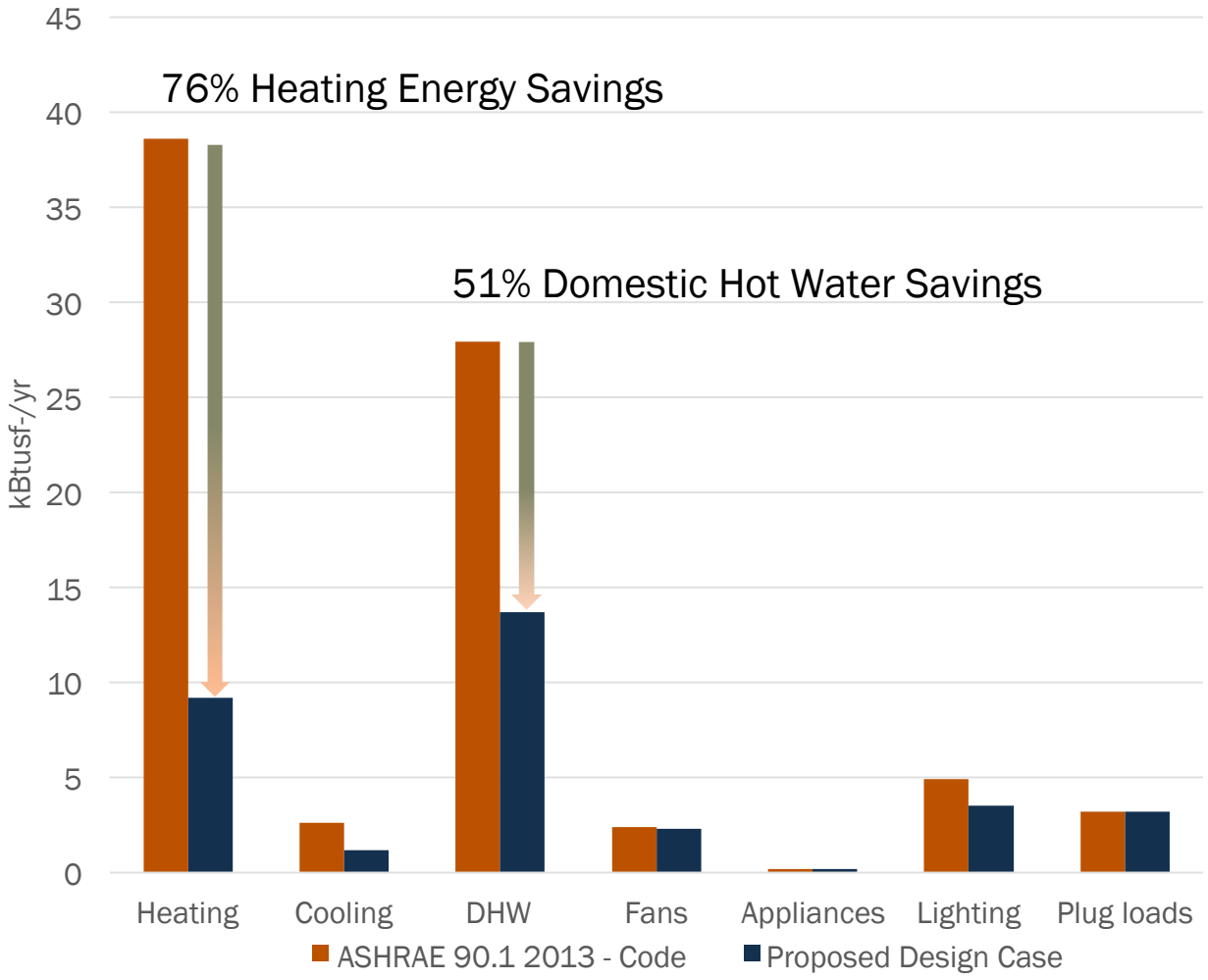
Energy Use Intensity Breakdown by End Use



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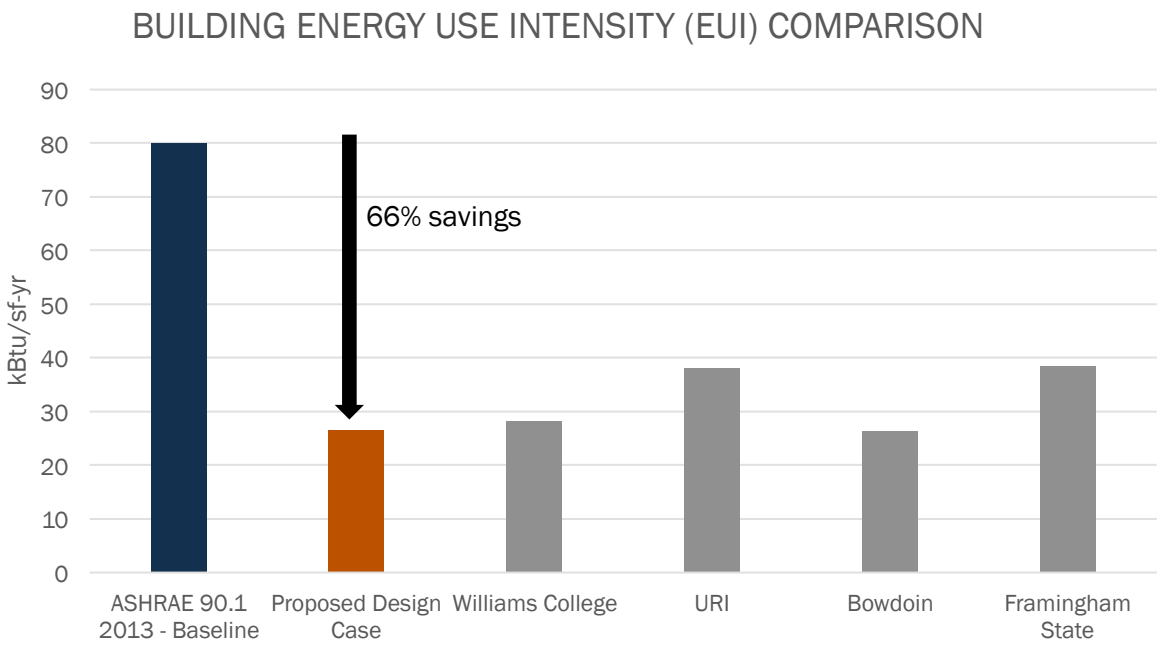
Site Energy Comparison (EUI)



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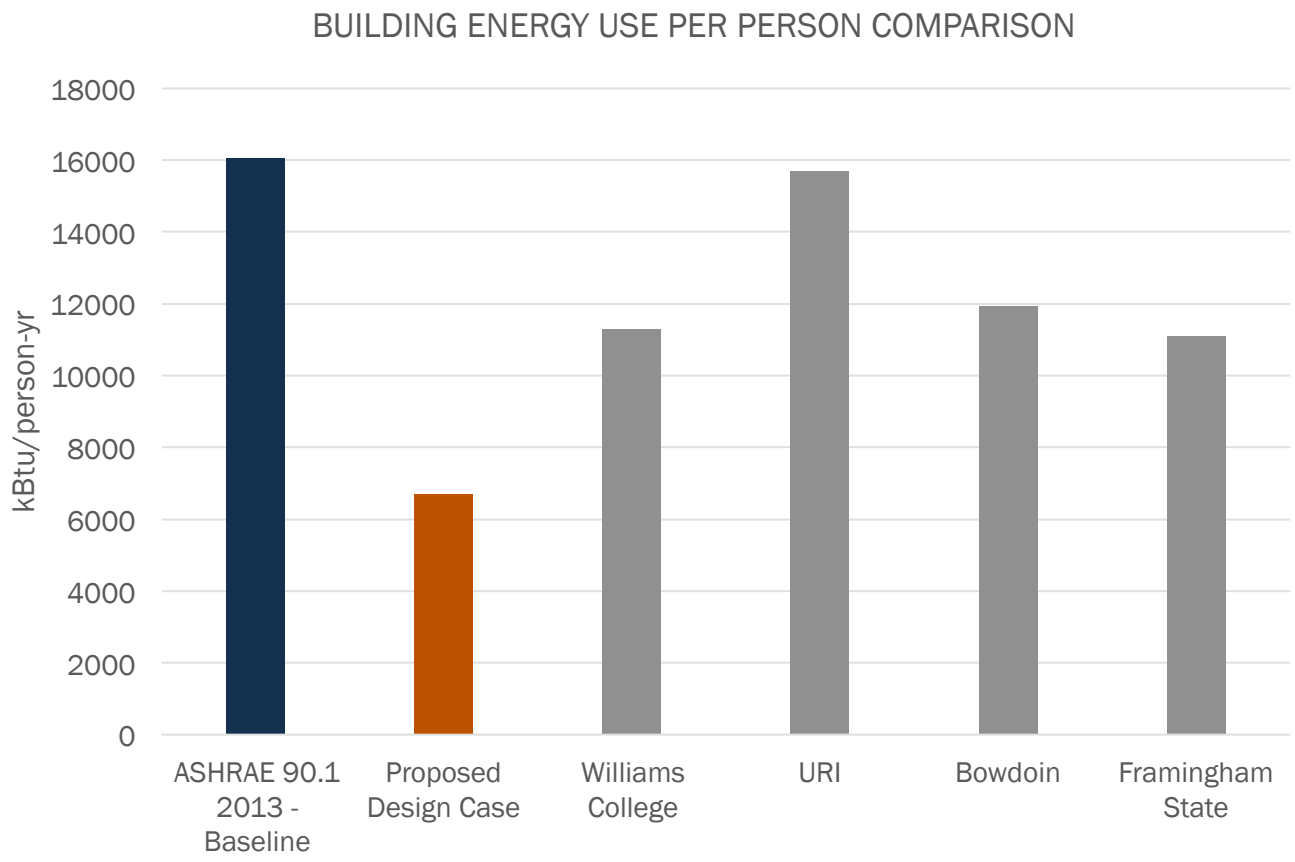
Site Energy Comparison (Per Person)



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Passive House
Analysis

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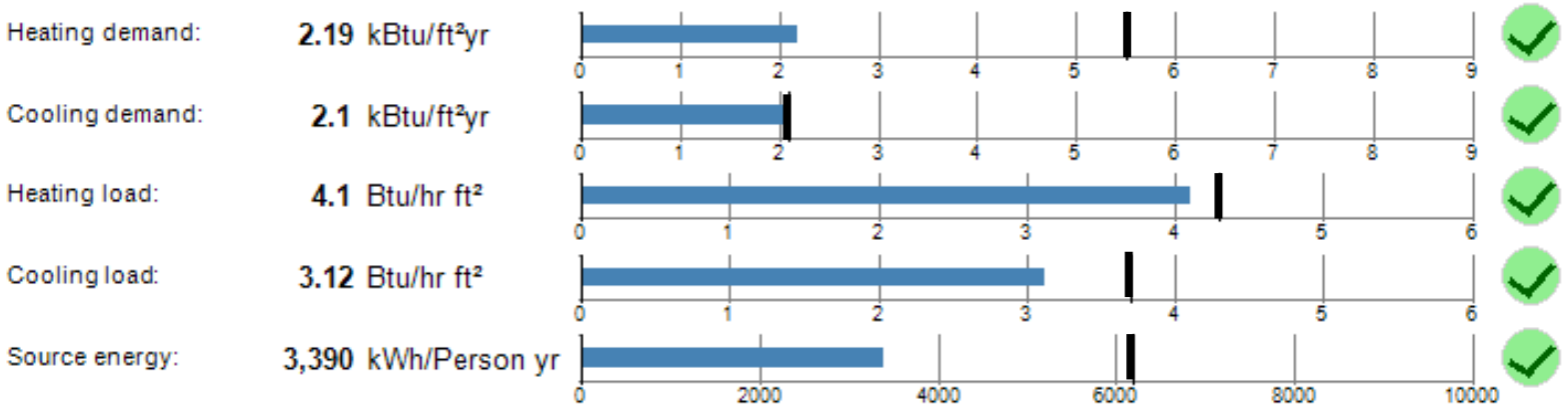
Wheaton College – Dormitory

Model Results Against PH Thresholds



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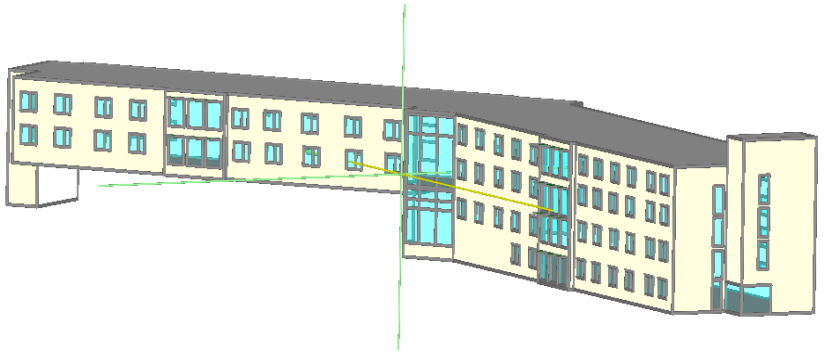
Wheaton College – Dormitory

Passive House Boundary

- Excluding First floor (flexible space)
- Separate metering: electric, chilled water, hot water, DHW
- Separate Ventilation (AHU)
- Separate Air Barrier



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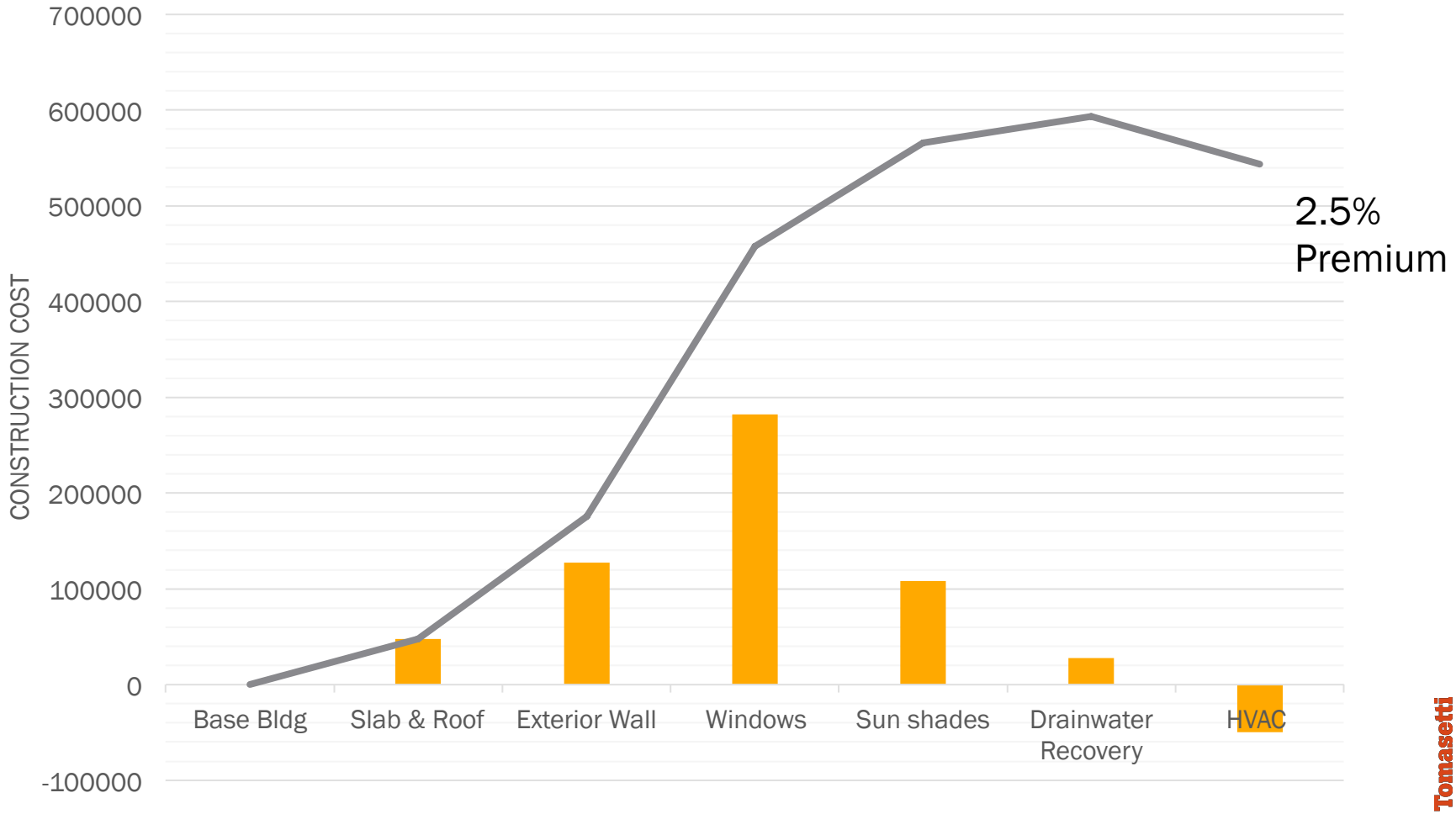
Cost Analysis for Passive House



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WUFI Passive Model Inputs

WUFI Passive Model Input Parameter	
Building Envelope	
Roofs Construction	Assembly R-50 (U-0.02)
Walls (Above Grade)	Assembly R-32 (U-0.02)
Ground Floor	R-20 (U-0.05)
Building Shell Area Infiltration	0.05 CFM/SF @ 50 Pascal's (PASSIVE HOUSE LEVEL)
Glazing U-factor (Punch windows)	Assembly U-0.20
Glazing U-factor (Curtainwall)	Assembly U-0.17
Vertical Glazing SHGC (Punch windows)	0.378
Vertical Glazing SHGC (Curtainwall)	0.20
Shading Devices	Horizontal overhangs on SW and W facades
HVAC (Air-Side)	**Proposed Case**
HVAC Systems	Campus steam (hot water), WSHP/Dry Cooler (chilled water), Valance unit (distribution)
Outside Air System	
Ventilation Supply Air / Exhaust Air	4060 CFM / 4060 CFM
Heat Recovery Device Type	Enthalpy Wheel 82% Effectiveness
Domestic Water Heating	**Proposed Case**
Heater Fuel	Condensing Gas boiler (95% efficient)
HW Demands	12 gallons/person/day
HW controls	Low flow fixtures, drain water heat recovery on showers
Lighting	**Proposed Case**
Lighting Power Density (LPD)	47682 kWh/yr (0.3 W/SF)
Miscellaneous	**Proposed Case**
Miscellaneous equipment	52659 kWh/yr
Photovoltaic Panels	
Generation (potential)	*139,000 kWh*

Thornton Tomasetti

Lessons Learned

Design Guidelines

- Glazing - <40% wall area for most cost effective PH design.
- Overheating – High SHGC glazing can cause overheating, use external shading cleverly.
- Curtainwall – Large glazed areas overheat quickly so limit to specific areas and provide shading
- Ventilation – Align ventilation calcs with MEP early, as they greatly impact heating/ cooling demand, energy
- ERVs – specify systems with high efficiency 84%+ Efficiency (Sensible heat recovery)
- Heating – keep it simple. You don't need much.
- Cooling – typically required, and can be a large energy consumer, so explore passive cooling (high thermal mass, phase change materials natural ventilation).
- Domestic Hot Water (DHW)– use drainwater heat recovery wherever possible.
- Thermal Bridging – eliminate thermal bridging concerns to the greatest extent possible, while using cost effective solutions

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THANK YOU.

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